The Palgrave Handbook of Managing Fossil Fuels and Energy Transitions

Edited by
Geoffrey Wood · Keith Baker

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To Neil Taylor, for always being there and being able to help me resolve any problems with a few clear words. RIP my friend (Dr. Geoffrey Wood).

To Sue Roaf, for being a friend, a colleague, and an inspiration (Dr. Keith Baker).

Foreword

When the Paris Agreement on climate change was adopted on 12 December 2015, the newspaper *The Guardian* dramatically heralded the "*end of* [the] *fossil fuel era*". It may perhaps have seemed like that at the time. After all, the agreement's goal of keeping global warming well below 2°C and it's even more ambitious aspirational goal of avoiding 1.5°C require a drastic reduction in the production and consumption of fossil fuels—the burning of which is still the single largest driver of human-induced climate change.

But while the Paris Agreement may have given a strong and clear signal that the decarbonisation of our energy systems is inevitable, a true decline of fossil fuels has yet to commence. Notwithstanding the increasing availability and rapidly falling costs of renewable energy sources, global fossil fuel consumption continues to grow, and fossil fuels have retained their high share in global electricity production. Even coal—arguably the dirtiest fossil fuel—is witnessing a resurgence due to growing demand in Asia. Fossil fuel production also shows no signs of abatement, and investment in fossil fuels continues to be stable. All over the world, governments support the production and consumption of fossil fuels, through licensing and permitting, as well as tax breaks and other subsidies. We are currently locked into fossil fuels, through existing infrastructure, institutions, and individual behaviour. Any transition away from them, therefore, will face considerable hurdles.

If we are to avert the climate crisis, however, such a transition is a must. We thus find ourselves at a critical juncture, about to embark on a very daunting journey. The good news is that, perhaps for the first time in the history of large-scale transitions, we have something of a compass. We can actually *plan* for this transition. This is why the present volume's focus on 'managing the decline' of fossil fuels is so important.

The climate imperative offers broad guidance on where our journey is headed. We know that meeting the Paris Agreement's temperature goals means we cannot afford to burn all fossil fuels, and that a major part of fossil fuels needs to be left in the ground. We also know that we need to significantly scale up the deployment of renewable energy sources, and that this requires sustained support from the public and private sectors. But we further know that not everyone can or should follow the same energy transition pathway. Countries have been unevenly endowed with resources (both fossil fuels and renewables), are not all equally responsible for causing the problem of climate change and have varying levels of economic development. So, while we may applaud countries like Costa Rica or Sweden for their ambition to become 'fossil free' nations, the challenge for countries like Angola or Indonesia will be much greater. We also see these disparities within countries. Some regions, communities, and workers dependent on fossil fuels will be disproportionately affected by the low-carbon energy transition. These international, national, and subnational equity and fairness dimensions underscore the necessity of a *just* transition, and more broadly the need to view energy transitions through the lens of energy justice.

Along with my colleagues at the Stockholm Environment Institute (SEI), and in collaboration with a range of think tanks, civil society organisations, and academics, I have sought in the past years to put these challenges, as well as possible responses, on the radar of climate and energy policy researchers and practitioners. Through SEI's initiative on Fossil Fuels and Climate Change, we have drawn attention to the importance of tackling fossil fuel supply alongside more traditional climate policy measures such as carbon pricing and energy efficiency standards. We have done so by organising workshops and conferences, producing academic publications, blogs, opinion pieces, and engaging with policymakers. From this work, it has become clear to me that while the evidence base for managing the decline of fossil fuels is expanding, concerted efforts are needed to diversify and consolidate the research connecting the dots between fossil fuels and climate change.

It is here where one of the present volume's main strengths lies. The book brings together perspectives from authors with a variety of disciplinary backgrounds, covering various key jurisdictions, and employing a range of approaches. Reflecting the multifarious challenge of the energy transition, insights from various disciplines—engineering, economics, political science, ethics, law, and more—are needed to better understand the underlying causes of our present carbon lock-in, and to sketch the possible ways to overcome this. With respect to jurisdictions, it is important to look both at countries where lessons on energy transitions are already emerging—as is the case, for instance, with the German *Energiewende*—as well as countries that still have a long way to go in moving away from fossil fuels, such as Australia and Russia. In terms of approaches, contributions should be looking at the drivers of continued fossil fuel supply, countervailing forces seeking to increase the share of renewables in the energy system, and interactions between them. Australian economists Fergus Green and Richard Denniss refer to this as "*cutting with both arms of the scissors*": we should not just be considering approaches that aim to reduce the demand of fossil fuels, but also determine how such approaches could work hand-in-hand with policies and actions restricting fossil fuel supply.

It remains to be seen whether the transition away from fossil fuels resemble what the editors term a 'long goodbye' or whether it will rather be more akin to falling off a cliff-edge. The latter—that is, an unmanaged decline—may lead to the stranding of assets, as well as the stranding of communities and countries dependent on the production and export of fossil fuels. The former requires, at a minimum, a recognition among governments, industries, and investors that we need to stop expanding our fossil fuel infrastructure, a shared vision of a post-carbon future, and a transparent and participatory planning process to achieve that future. The longer we fail to fully embrace the long goodbye, however, the more likely it is that the cliff-edge scenario will become a reality.

Throughout, we should also remain aware of the real possibility of a fossil fuel *renaissance*. This could happen, for instance, through the introduction of new technologies such as carbon capture and underground storage or the switching from higher-carbon to lower-carbon (but still fossil-based) fuels, such as from coal to natural gas. In addition, what German economist Hans-Werner Sinn dubbed the 'green paradox' may materialise: in such a scenario, increased production of fossil fuels takes place *because of* increasing carbon constraints.

These possibilities suggest that, unlike what *The Guardian* claimed in 2015, the era of fossil fuels is not over yet. As this book makes abundantly clear, however, its time has certainly come.

Harro van Asselt

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Keith Baker is a Researcher at the Built Environment Asset Management (BEAM) Centre, Glasgow Caledonian University, and a Co-founder of the Energy Poverty Research initiative. He specialises in fuel poverty and energy policy, with a particular focus on the provision of renewable heat. His recent work includes the development of a complexity and risk-based assessment of fuel poverty, and a series of policy papers for Common Weal, a Scottish 'think and do' tank, covering energy performance certificates, Scotland's National Energy Company, and developing successful district heating schemes. His activities also include regular articles and appearances in the media, and he has been described by James Whale, a 'shock jock' on the UK's talkRADIO, as "the acceptable face of climate change".

Rick Bosman's work focusses on the energy transition, both in the Netherlands and abroad. He is especially interested in processes of regime destabilization, and how this creates the necessary space for transitions to occur. He combines his academic work with advisory projects, publishing for popular media, and is a frequently invited speaker and lecturer. He is currently coordinating a research program into the cooperation between bottom-up and traditional energy production and is pursuing his PhD as part of this project. He has a background in Renewable Energy Management and Environmental Sciences.

Stefan Bößner is an independent research consultant based in France, working in the fields of energy, climate and sustainability. He has worked as a researcher and a project manager for leading think tanks, research institutes and consulting companies, in France, Lebanon and the United Kingdom, most recently for the Stockholm Environment Institute's Oxford office, and he currently remains an Associate at the Stockholm Environment Institute's HQ in Stockholm. In his work he focused on sustainability transitions, international climate policies as well as on developments in the energy sectors of Germany, Indonesia and Thailand. Stefan holds a master's degree in International Relations from Sciences Po University in Paris and a master's degree in Media Studies from the University of Vienna.

Ioan Charnley-Parry is a postdoctoral energy and social science researcher in the Lancashire Institute for Citizenship, Society and Change and the Energy and Society Research Group at the University of Central Lancashire, Preston, UK. He has worked closely with energy communities, particularly young people and the agricultural community.

Pooja Chatterjee is a senior associate at Cyril Amarchand Mangaldas's Infrastructure and Project Finance Group. She has an extensive and diverse experience in energy and infrastructure projects as well as project financing transactions. She represents and advises developers, sponsors, lenders and contractors in projects and project finance transactions. She is also involved in various infrastructure sectors, including energy, transportation and mining.

Andrew Fredrick Crossland, CEng, is a developer of renewable energy projects and a specialist in the interdisciplinary analysis of whole energy systems. His PhD compared different ways of installing energy storage in low voltage electricity networks which predicted the commercial viability of domestic energy storage. After getting his PhD in 2015 and completing research on social, economic and technical impacts on microgrid design in East Africa, Crossland is now an Associate Fellow at Durham Energy Institute and a specialist in decarbonisation projects across the Pacific, New Zealand and South-East Asia at Infratec. He founded his company, Advance Further Energy Ltd, and provides specialist consultancy on energy projects and standards. In 2016, Crossland founded and continues to run the electricity and carbon tracking website MyGridGB, inadvertently becoming an advocate for good energy knowledge. As a result of this work he won the "Rising Star" Award with EnergyUK in 2017 and released his first book on renewable energy *Decarbonising Electricity Made Simple* in 2019. He continues to work on global energy projects, consumer protection for solar PV in the UK and in developing capacity for renewable energy in utilities around the world.

Paul Dorfman is Honorary Senior Research Associate, UCL Energy Institute, University College London; Nuclear Policy Research Fellow, Joseph Rowntree Charitable Trust; Founder of the Nuclear Consulting Group; Member of the Irish Govt. Environment Protection Agency Radiation Protection Advisory Committee; Executive Board member of the International Nuclear Risk Assessment Group. Paul served as Secretary to the UK Govt. scientific advisory Committee Examining Radiation Risks from Internal Emitters, led the European Environment Agency response to Fukushima, was Expert to the European Economic and Social Committee, and served as Advisor to the UK Ministry of Defence nuclear Submarine Dismantling Project.

David Elliott is Emeritus Professor of Technology Policy at the Open University. He worked initially with the UK Atomic Energy Authority at Harwell and then for the Central Electricity Generating Board in Bristol, before moving, in the early 1970s, to the Open University, where he carried out research and developed courses on technological innovation, focusing in particular on renewable energy technology development policy. Prof. Elliott has written extensively on sustainable energy policy and is co-editor of Palgrave Macmillan's Energy, Climate and Environment monograph series, and also editor the long-established journal, Renew (https://renewnatta.wordpress.com).

Daniel Gilbert is an Associate member of staff of the University of Dundee's Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP), and also a Masters-level alumnus of both CEPMLP, University of Dundee, and the Politics department of the University of Edinburgh. He is the recipient of the 2015 Energy, Petroleum, Mineral and Natural Resources Law & Policy Education Trust's £1,000 Management Prize for the best performing Masters-level Management student at CEPMLP. Daniel has undertaken commercial research consultancy globally on a range of extractive industries projects, including on India's coal sector, and also on behalf of the Scotland Malawi Partnership and Malawi Scotland Partnership, research conducted over the length and breadth of Malawi. Daniel publishes on a wide range of natural resources topics, including water resources for which he is an award-winning author. He is a founding member of, and advisor to, the Dundee Africa Research Network, and a former member of staff of the universities of both Aberdeen and University College London.

Mohammad Hazrati is a PhD researcher at the Centre for Commercial Law Studies (CCLS) at Queen Mary University of London. He is also a Research Assistant for Energy Law and Policy at the University of Dundee. He studied oil and gas law (LLM) at Reading University. His research and expertise are particularly focused on energy justice in Canada, Iran, Malaysia and the United Kingdom.

Marc Hudson recently successfully defended his PhD at The University of Manchester. His thesis was entitled 'Enacted inertia: incumbent resistance to carbon pricing in Australia (1989–2011)'. He has had articles published in Technology in Society, Energy Research & Social Science and Environmental Politics (he is also social media editor for that journal). He is currently a Research Associate at the University of Manchester, looking at both platform capitalism's implications for urban mobility, and the networks around carbon finance advocacy. Formerly a physiotherapist, he is a long-term climate change activist in Manchester, who is intensely pessimistic about our species capacity to survive the twenty-first century.

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Sem Oxenaar works as both a researcher and advisor at DRIFT (Erasmus University Rotterdam) focusing on the energy transition and natural resource issues. He is especially interested in how different actors can influence and accelerate transitions and what tools they have at their disposal to do so. He combines academic research with advisory and applied research projects, mainly for governments, and lectures on transitions theory and sustainability transitions. He holds an MSc. in Integrated Natural Resource Management from the Humboldt University in Berlin (2017), and a Bachelor's degree in economics and environmental policy from Amsterdam University College (Honours, 2012). Currently he is involved in several national and international projects on themes as energy prosumption, the circular economy, sustainable mobility, and natural capital, and he is teaching on transitions theory.

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Geoffrey Wood is a Lecturer in International Energy Law and Policy at the School of Law, University of Stirling. An energy and environmental law, policy and regulatory specialist, his work focuses on the development of legal and governance frameworks for sustainable energy transitions to optimise policy delivery in terms of environmental, social, economic, political and technological outcomes. Recent work includes exploring the impact of austerity on environmental decision making in Scotland, a critical analysis of policy risk and politics on low carbon energy deployment in the UK and Scotland, the role of definitions in renewable and low carbon energy governance, and the book 'A Critical review of Scottish Renewable and Low Carbon Energy Policy' (Palgrave Macmillan, 2017). He has published extensively on energy and environmental issues, and has published over 30 articles, books, book chapters and other publications. Geoff has previously held research, lecturing and consultancy positions for various organisations, including the Scottish Government, University of Dundee, Offshore Renewables Institute, Royal Society of Edinburgh and the joint UK Department for International development-University of Dundee led Extractives Hub project.

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Note on Units

Power units	The power using or generating capacity of devices is measures in watts (W), or more usually kilowatts (kW) (1 kW = 1,000 W). Larger units are megawatts (MW) (1,000 kW), gigawatts (GW) (1,000 MW) and terawatts (1,000 GW).
Energy units	The kilowatt-hour (kWh) is the standard unit by which electricity is sold—1 kWh is the energy produced/consumed when a 1 kW rated generator/energy consuming device runs for 1 hour (h). A megawatt-hour (MWh) is 1,000 kWh. Similarly, 1,000 MWh = 1 GWh, and so on.

Abbreviations

A2F	Air to Fuel (or Synfuel Approach)
ACER	Agency for the Cooperation of Energy Regulators (EU)
AD	Anaerobic Digestion
AEMC	Australian Energy Market Commission
AfDB	African Development Bank
AGA	Australian Gas Association
AIGN	Australian Industry Greenhouse Network
ALP	Australian Labor Party
AMIC	Australian Mining Industry Council
ASHP	Air Source Heat Pumps
ATIA	Australian Trade and Industry Alliance
BCA	Business Council of Australia
BCM	Billion Cubic Meter
BECCS	Biomass with Carbon Capture and Storage
BECCU	Biomass Carbon Capture and Utilisation
BEIS	Department for Business, Energy and Industrial Strategy (UK)
BMT	Billion Metric Tons
BOE	Barrels of Oil Equivalent
BOEPD	Barrels of Oil Equivalent Per Day
BPD	Barrels of Oil Per Day
BU	Billion Units
CAPEX	Capital Expenses
CCC	Committee on Climate Change (UK)
CCGT	Combined-Cycle Gas Turbines
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CCUS	Carbon Capture, Utilisation and Storage
CDIAC	Carbon Dioxide Information Analysis Centre

CEA	Compound Annual Growth Rate (India)
CEFC	Clean Energy Finance Corporation (Australia)
CEO	Chief Executive Office
CEPS	Central European Pipeline System
CFL	Compact Fluorescent Lamps
CHP	Combined Heat and Power
CIL	Central India Limited
CMAL	Coal Mines Authority Limited (India)
CO_2	Carbon Dioxide
COMECON	Council of Mutual Economic Assistance and Cooperation (between USSR and the then Socialist States of Eastern Europe)
COP-21	(Conference of Parties-21)—Paris Climate Agreement 2015
COVA	Stichting Centraal Orgaan Voorraadvorming Aardolieproducten (The Netherlands)
CPF	Central Processing Facility
CPP	Captive Power Plant
CPRR	Current Proven Recoverable Reserves
CPRS	Carbon Pollution Reduction Scheme (Australia)
CRISIL	Credit Rating Information Services of India Limited
CRM	Capacity Remuneration Mechanisms
CSP	Concentrated Solar Power
CUF	Capacity Utilisation Factor
DEC	Department of Environmental Conservation (US)
DECC	Department for Energy and Climate Change (Defunct, Replaced By BEIS) (UK)
DGAD	Directorate of Anti-Dumping and Allied Duties (India)
DHS	District Heating Systems
DISCOM	Electricity Distribution Company (India)
DPO	Defensie Pijpleidingen Organisatie (The Netherlands)
DRC	Democratic Republic of Congo
DSM	Demand-Side Management
E&P	Exploration and Production
EAPP	Eastern African Power Pool
EASAC	European Academies' Science Advisory Council
EBN	Energie Beheer Nederland (The Netherlands)
EBRD	European Bank for Reconstruction and Development
ECE	Eastern and Central Europe
ECOWAS	Economic Community of West African States
ECSC	European Coal and Steel Community
EDF	Electicité De France (France)
EEG	Erneuerbare-Energien-Gesetz (German Renewable Energy Act)
EFR	Enhanced Frequency Response
EIA	Environmental Impact Assessments

EIA	Environmental Information Administration (US)
EIS	Emissions Intensity Scheme (Australia)
EITI	Extractive Industries Transparency Initiative
Eneco	Eneco Groep N.V (The Netherlands)
ENGO	Environmental Non-Governmental Organisations
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency (US)
EPR	European Pressurized Reactor
ERC	Energy Research Center (Russia)
ESP	Energy Sector Plan (SADC Region, Africa)
ETS	Emissions Trading System
EU	European Union
EU-ETS	European Union Emissions Trading System
EV	Electric Vehicles
EXIM	Export Import Policy
FERC	Federal Energy Regulatory Commission (US)
FGD	Flue-Gas Desulphurisation
FiT	Feed-in Tariff
FMF	Free Market Fundamentalism
FOE	Friends of the Earth
GBP	Great British Pounds
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoI	Government of India
GOSPLAN	USSR State Planning Committee (Ex: USSR)
GSHP	Ground-Source Heat Pumps
GSP	Groningen Seaports (The Netherlands)
GT	Gigatons
HELE	High Efficiency Low Emissions
HGS	Humber Gathering System (UK)
HIE	Highlands and Islands Enterprise (Scotland)
HP	Horsepower
HPC	Hinkley Point C (UK)
HRF	Hydraulic Reservoir Fracturing
HSPS	Heron Sub-Sea Pipeline System
IAEA	International Atomic Energy Association
IEA	International Energy Association
IGCC	Integrated Gasification Combined Cycle
Imeche	Institute of Mechanical Engineers (UK)
IMEMO	E. M. Primakov Institute of World Economy and International Relations of the Russian Academy of Sciences (Russia)
INR	Indian Rupee
IOC	International Oil Cartel

IPA	Institute of Public Affairs (Australia)
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRENA	International Renewable Energy Association
ISDS	Investor-State Dispute Settlement
ISO	Independent System Operators
JKM	Japan-Korea Market (for LNG)
KM	Kilometre
KSA	Kingdom of Saudi Arabia
LCOE	Levelised Cost of Electricity
LHEES	Local Home Energy Efficiency Strategy (Scotland)
LNG	Liquefied Natural Gas
LNP	Liberal National Party (Australia)
LRMC	Long-Run Marginal Costs
LTGEC	Long Term Gas Export Contract
LTS	Long Term Low-Emissions Strategy (UK)
MCA	Minerals Council of Australia
MEMR	Ministry of Energy and Mineral Resources (India)
MER	Maximising Economic Recovery (UK)
MIT	Massachussets Institute of Technology (US)
MLP	Multi-Level Perspective
MMBO	Million Barrels of Oil
MMBPD	Million Barrels of Oil Per Day
MMBTU	Million British Thermal Units
MMT	Million Metric Tonnes
MNRE	Ministry of New and Renewable Energy (India)
MO	Market Operator
MoC	Ministry of Coal (India)
MoEF	Ministry of Environment and Forests (India)
MoP	Ministry of Power (India)
MPCCC	Multiparty Committee on Climate Change (Australia)
MT	Metric Tonne
MUP	Multi-Use Platform
MUSES	Multi-Use in European Seas
NAM	Nederlandse Aardolie Maatschappij (The Netherlands)
NAO	National Audit Office (UK)
NAPCC	National Action Plan on Climate Change (India)
NATO	North Atlantic Treaty Organization
NDA	Nuclear Decommissioning Agency (UK)
NDC	Nationally Determined Contribution
NDRC	National Development and Reform Commission (China)
NEA	National Energy Administration (China)
NEM	National Electricity Market (Australia)

NEP	National Energy Policy (India)
NET	Negative Emission Technologies
NGO	Non-Governmental Organization
NIC	National Infrastructure Commission (UK)
NO_x	Nitrogen Dioxide
NOC	National Oil Companies
NOPR	Notice of Proposed Rulemaking (US)
NPP	Nuclear Power Plant
NRDC	Natural Resources Defense Council (US)
NRES	Non-Renewable Energy Sources
NSIP	Nationally Significant Infrastructure Projects (UK)
NSW	New South Wales (Australia)
NUI	Normally Unattended Installation
NYC	New York City (US)
NYCDEP	NYC Department of Environmental Protection (US)
NYSERDA	New York State Energy Research Development Authority (US)
OECD	Organization for Economic Cooperation and Development
OFGEM	Office of Gas and Electricity Markets (UK)
OGA	Oil and Gas Authority (UK)
OGTC	Oil & Gas Technology Centre (UK)
OPEC	Organisation of Petroleum Exporting Countries
OPEX	Operational Expenses
P2G	Power to Gas
PEM	Proton-Exchange Membrane
PJ	Peta Joule
PLEX	Plant Life Extension
PMT	Population Mixing Theory
POWER	Partnerships for Opportunity and Workforce and Economic Revitalization Initiative (US)
PPA	Power Purchase Agreement
PP-indexation	Indexation to Petroleum Products (in contractual gas pricing)
PRA	Probabilistic Risk Assessment
PROBEC	Programme for Biomass Energy Conservation (SADC Region, Africa)
PSA	Production-Sharing Agreement
PTC	Production Tax Credit (US)
PV	Photovoltaic (Solar)
QRC	Queensland Resources Council (Australia)
R&D	Research & Development
RE	Renewable Energy
REASAP	Regional Infrastructure Development Master Plan (SADC Region, Africa)
REC	Renewable Energy Certificates

REEESAP	The Renewable Energy And Energy Efficiency Strategy & Action Plan (SADC Region, Africa)
RERA	Regional Electricity Regulatory Association (SADC Region, Africa)
RES	Renewable Energy Sources
RF	Russian Federation
RMB	Renminbi (Chinese Currency)
ROI	Return On Investments
RPO	Renewable Purchase Obligation (India)
RTO	Regional Transmission Operators
SADC	Southern African Development Community
SAPP	Southern Africa Power Pool
SASAC	Assets Supervision and Administration Commission (China)
SDP	Social Democratic Party (Germany)
SEB	State Electricity Board (India)
SEEP	Scotland's Energy Efficiency Programme
SES	Scottish Energy Strategy
SHAKTI	Scheme for Harnessing and Allocating Koyala (Coal) Transparently In India
SLO	Social Licence to Operate
Sm3	Standard Cubic Meter
SMR	Small Modular Reactors
SO	System Operator
SO_2	Sulphur Dioxide
SOE	State-Owned Enterprise
SRMC	Short-Run Marginal Costs
SSA	Sub-Saharan Africa
STP	Scientific and Technological Progress
SWF	Shale Wealth Fund (UK)
TCF	Trillion Cubic Feet
TCM	Trillion Cubic Metres
TNO	Nederlandse Organisatie Voor Toegepast-Natuurwetenschappelijk Onderzoek (The Netherlands)
TPP	Thermal Power Plants
TTF	Title Transfer Facility
UGD	Unconventional Gas Development
UK	United Kingdom of Great Britain and Northern Ireland
UKCS	United Kingdom Continental Shelf
UMPP	Ultra-Mega Power Project
UN	United Nations
UNDP	UN Development Program
UNEP	UN Environmental Program
UNESCO	United Nations Educational Scientific and Cultural Organization

UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund (or UN Children's Fund)
USA/US	United States of America
USAID	United States Agency for International Development
US FRS	US Federal Reserve System
USSR	Union of Soviet Socialist Republics
VIOC	Vertically Integrated Oil Company
VOLL	Value of Lost Load
WEC	World Energy Council
WHO	World Health Organization
ZSP	Zeeland Seaports (The Netherlands)

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Part I

Introduction

1

Fossil Fuels in a Carbon-Constrained World

Geoffrey Wood

1 Aim of the Book

The *Handbook of Managing Fossil Fuels and Energy Transitions* focuses attention on the need to manage the decline of fossil fuels as the world shifts towards a low-carbon energy transition. The premise of the book is straightforward: although fossil fuels have powered the industrialisation of many nations and improved the lives of hundreds of millions of people, another century dominated by fossil fuels would be disastrous. On the one hand, fossil fuels are responsible for the majority of the increase in greenhouse gas (GHG) emissions, and projected increases in oil, gas and coal demand are incompatible with the Paris Agreement on Climate Change (United Nations Framework Convention on Climate Change (UNFCCC), 2018). On the other hand, although the demise of fossil fuels has been often predicted, they have proved remarkably resilient and with low prices and superabundant resources they are likely to play a role in world energy going forward. This should not detract from the problems that their continuing use poses to the planet. In 2018, the UN Intergovernmental Panel on Climate Change (IPCC) issued a stark warning that humanity has just twelve years to limit global warming to below 2°C (IPCC, 2018). This is not an arbitrary target. It is a red-line, a warning built on decades of scientific evidence-based research to avoid rising temperatures

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and rising risks, including threats to ecosystems, biodiversity, extreme weather events, sea level rises and unprecedented stresses to human economic, social and political systems. Yes, there is uncertainty in the consequences of inaction. Uncertainty is inherent to the complex problem of climate change that humanity faces.[1] However, for the discerning observer of the spectre of global catastrophe this induced a feeling of justifiable fear. But in any discussion focused on addressing climate change, two factors come to mind: the opportunities made possible by low carbon energy and discussions of the resultant decline of fossil fuels. Although this is a simplification of the issues,[2] what appears certain is that given the enormity of the problems fossil fuel use and the emissions and pollutants thereof must decrease. The question arises as to how the necessary decline of fossil fuels will be managed, if it is indeed managed, and the pace that this change requires. This leads to a key theme of the book: whether it will be a '*long goodbye*' to fossil fuels or not? As this book argues, the reality is not so straightforward.

Ostensibly, accounts of the increasingly important role that low carbon energy plays in addressing the risks of climate change appear positive, evidenced by record levels of global investment and capacity additions in recent years (Wood, 2018). This trend has been particularly notable in the renewable electricity (RES-E) sector, leading to the attainment of milestones unthinkable a few years ago. In 2017 almost 180 GW of renewable electricity (RES-E) capacity was added worldwide, more than for all fossil fuels combined, with more solar photovoltaic (PV) capacity added than for coal, gas and nuclear power combined (Renewable Energy Network (REN), 2019). An estimated 17 countries generated more than 90% of their electricity from RES-E, which is now the leading source of power generation in the European Union (EU), and this success is being repeated at the nation level including Uruguay, Nicaragua, Costa Rica, Kenya, Austria, Denmark, Latvia, Portugal, Sweden and Scotland (Climate Council, 2019; EU, 2017; Wood and Baker, 2017). In 2017, United Kingdom (UK) RES-E capacity surpassed coal, gas and oil-fired power plants for the first time on the back of a tripling of renewable capacity and a fall by one-third in fossil fuel capacity (Vaughan, 2018) heralding one week in May 2019 without using coal to generate electricity since 1882 (Jolly, 2019).

[1] Climate change has been called a 'Wicked Problem' as it is difficult or impossible to solve for as many as four reasons: incomplete or contradictory knowledge, the number of people and opinions involved, the large economic burden, and the interconnected nature of these problems with other problems (Wood, 2016).

[2] This spectrum of change must also include the way in which we fundamentally produce, use and consume energy. For more information on the requirements for the low carbon energy transmission refer to the Energy Transitions Commission (2019).

Nonetheless, fossil fuels continue to dominate the energy landscape, accounting for 86% of primary energy consumption in 2015, a mere 1% reduction from that recorded in 2005. Omitting nuclear power (4.4%), renewables accounted for approximately one-tenth of global primary energy consumption. The heat and transport sectors, although evidencing growth in renewable sources, continue to be dominated by fossil fuels. The power generation sector follows the same trend, with fossil fuels accounting for over two-thirds of the fuel share in global power generation (BP, 2018; World Energy Council, 2016), and 80% of global total final energy consumption (REN, 2019). Of the remaining 20%, nuclear power and renewables account for 2% and 10%, respectively, with the rest from traditional biomass (REN, 2019), hardly an environmentally friendly fuel source. Yet the power sector is supposedly the 'low hanging fruit' in terms of decarbonisation, and the one sector that has witnessed huge growth in renewables. As Spencer Dale, Group Chief Economist at BP put it:

> The most striking—and worrying—is the trends in the power sector fuel mix over the past 20 years… despite extraordinary growth in renewables in recent years, and the huge policy efforts to encourage a shift away from coal into cleaner, lower carbon fuels, there has been almost no improvement in the power sector fuel mix over the past 20 years. The share of coal in the power sector in 1998 was 38%—exactly the same as in 2017… *Global energy markets in 2017 took a backward step in terms of the transition to a lower carbon energy system*; growth in energy demand, coal consumption and carbon emissions all increased… follow[ing] three consecutive years of little or no growth in carbon emissions. (BP, 2018: 6–7, emphasis added)

Numerous reasons are put forward to explain this '*backward step*', including falling fossil fuel costs and recent price competitivity between gas and coal in favour of the latter. But what about the role of energy policy? In the context of warnings about climate change, energy policy is an important tool for policy and decision makers, namely to constrain the development and deployment of fossil fuels, reduce carbon 'lock-in' (Unruh, 2000) and drive low carbon energy. Yet despite decades of global experience in supporting renewable energy technologies (RETs), a developing corpus of low carbon and renewable energy law, policy, regulations and guidance (a 'low carbon energy law and policy framework') and rapid falling costs (International Renewable Energy Agency (IRENA), 2017), the share of low carbon power generation in the global energy mix has effectively stagnated in relative terms. Coal use is up. Carbon emissions are up. Time is almost up.

Instead of talking about global energy markets taking a backward step, we should be proclaiming '*forward steps*' in relation to global efforts to mitigate climate change. In reality, modelling estimates paint a pessimistic future, one where fossil fuels continue to gain market share to 2030 on the back of increasing energy demand, albeit at different speeds: oil (0.8%), coal (1.2%) and gas (2%) per year (BP, 2013), with overall growth in part due to strong growth in production from unconventional gas and oil. All-in-all, although renewables are expected to continue to be the fastest growing energy source (7.6%), the global fossil fuel share will remain more-or-less constant.

Therefore, the global energy system is at a critical juncture: we need to ensure the reduction and replacement of fossil fuel use and to avoid the fossil fuel industry from reaching a cliff-edge, resulting in the stranding of assets, loss of jobs and revenues for governments around the world. At the same time, any such approach needs to take into account the needs and contexts of different countries around the world (e.g. capacity short/excess, developing, developed, etc.). A nuanced understanding of the fossil fuel sector is critical to this.

This is all the more important given that the decline of fossil fuels, managed or otherwise, will have significant, multiple, interrelated and largely unknown repercussions as we enter a new phase of geopolitics, with resultant impacts to existing and future relations, politics and trade between countries. As the Global Commission on the Geopolitics of Energy Transformation (2019: 12) recently pointed out:

> Fossil fuels have shaped the geopolitical map over the last two centuries… the energy transformation will alter the global distribution of power relations between states, the risk of conflict, and the social, economic and environmental drivers of geopolitical instability… These far-reaching effects have not previously been considered in a comprehensive manner.

At the same time, understanding how to manage the decline of fossil fuels must look beyond the range of demand-side solutions for climate change, including global GHG mitigation targets and sectoral targets, performance standards, behavioural policies, carbon pricing mechanisms, energy efficiency and low-carbon technologies (Mundaca et al., 2019). Demand-side climate policies have been successful but only to an extent, and an insufficient one despite decades of effort. As Lazarus and van Asselt (2018: 1) point out, "*Focusing on the point of combustion makes intuitive sense, but efforts so far have yet to put fossil fuel use on a trajectory consistent with keeping global warming well below 2°C and pursuing efforts to stay below 1.5°C, as suggested by the Paris*

Agreement." The authors go on to point out the need to look at the supply-side of the fossil fuel economy, termed 'supply-side climate policies' and defined as measures to influence the pace and location of fossil fuel extraction to complement and enhance traditional demand-side climate policies:

> A key insight driving these new approaches is that the political and economic interests and institutions that underpin fossil fuel production help to perpetuate fossil fuel use and even to increase it. From this emerging vantage point, continued investment in fossil fuel exploration, extraction, and delivery infrastructure makes global climate protection objectives much harder to achieve. (Lazarus and van Asselt, 2018: 1)

This book is one of the first attempts[3] to comprehensively consider these effects with a focus on managing the decline of fossil fuels in light of the ongoing energy transition.

With the majority of nations already embarked on a low-carbon energy transition in attempting to mitigate climate change, with emphasis on renewable and low-carbon energy technologies, this book focuses on a number of relevant issues. These include: What approaches should be adopted to incentivise countries and companies to reduce the use of fossil fuels? How realistic is the 'swapping' of fossil fuels for cleaner alternatives (e.g. coal to green gas, petroleum to biofuels, gas to biogas)? What about managing baseload, traditionally taken on by fossil fuels? How can we manage such approaches given the apparent paradox of reducing fossil fuel use but avoiding impacts on economics, job loss and reduction in revenues? What is the impact on developing countries in comparison to developed countries? Are there any specific issues that need to be addressed in this respect? What role and/or opportunities exist for developing nations? What of the future of carbon capture and storage: is it the silver bullet for the continued use of 'clean' fossil fuels? What is the future of gas? Is it a valid transition fuel? Does coal have a future? What about biomass (e.g. CCS/co-firing)? How can the tensions between centralised and decentralised energy systems be addressed? Are unconventional hydrocarbons the future or a last gasp of the fossil fuel industry? What role can the energy justice agenda play in managing the decline of fossil fuels? Are markets and regulations adapted to manage a decline in fossil fuels for a renewable future? Are replacement options for fossil fuels more benign that the technologies

[3] In addition to the report by the Global Commission, see also the Climatic Change Special Edition 'Fossil Fuel Supply and Climate Policy' (van Asselt and Lazarus, 2018); 'The Sky's Limit: Why the Paris Climate Goals Require a Managed Decline of Fossil Fuel Production' (Muttitt, 2016); and 'A Managed Decline of Fossil Fuel Production' (Heinrich Böll Stiftung, 2018).

they seek to replace? How do we manage the issue of diesel, particularly for rural/island/peripheral communities and industries? What is the role of energy storage if we move from baseload or flexible fossil fuel generation to intermittent renewable energy sources?

The question of how to manage the decline of fossil fuels is also fundamentally linked to the type, definition and goals envisaged for low carbon energy transition. Reflecting this heterogeneity, the contributors to this book approach the energy transition from a range of perspectives and theoretical and methodological approaches. In itself, this echoes the uncertainty and diversity loaded in the term system change: do we mean transition or transformation when we talk about energy transition?[4] A strong thrust throughout the book is the concept of justice, whether energy, social and/or environmental. Energy justice is a relatively new agenda which seeks to apply principles of justice to energy and climate change (Jenkins et al., 2015) to guide how the management of energy resources should proceed, with implications not just for low carbon energy sources but also fossil fuels. Endeavours to manage the decline of fossil fuels also require inter- and multi-disciplinary collaboration. The authors contributing to this book reflect this, featuring renowned scholars and practitioners coming from and/or working in a range of disciplines including Built Environment, Business, Philosophy, Political Science, Economics, Engineering, Governance, Innovation, Law, Policy, Political Economy, Regulation, Sustainable Consumption, and Technology. They provide a rich contextualised approach to problem-solving how to manage the decline of fossil fuels.

This list is not exhaustive. Clearly that would be impossible in one volume. However, it has been the editors intention to capture and critically analyse the complexity of managing the decline of fossil fuels in what must be an increasingly carbon constrained world. As such, the book spans a broad range of related 'territories'. The chapters look at different energy technologies and sources including fossil fuels (coal, oil, gas, unconventional hydrocarbons), carbon mitigation technologies (carbon capture and storage/utilisation), low carbon options (nuclear), renewables (wind, solar, biomass, geothermal, biofuels) and energy storage (batteries, pumped hydro, demand side), electric vehicles, energy sectors (heat, transport and power), jurisdictions and different governance approaches encompassing multi- and inter-disciplinary technological, environmental, social, economic, political, legal and policy perspectives with timely case studies from Africa, Asia, Australasia, Europe,

[4] See Hölscher et al. (2017) on the differences between transition and transformation in understanding and interpreting system change.

the Pacific, North America and South America. We hope that the studies included in this book, and the gaps in the range of topics covered, provide fertile territories for researchers from around the world to build on the findings of this edited book. Given the urgency in addressing climate change, we welcome this.

2 Rising Temperatures, Rising Risks: Accepting the Reality of Climate Change

One point that we felt must be made clear is that any discussion on fossil fuels has to take into account the science on climate change. Simply put, the reality of anthropogenic climate change is accepted and it is no longer appropriate to deny this reality:

> Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea levels have risen. Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. (IPCC, 2014: 2)

This does not mean that research into climate change should go unscrutinised; we should always challenge ourselves to improve our understanding. However, this book does not purport to revisit the science, debates and issues concerning anthropogenic climate change. Other researchers and organisations have done so, and admirably.[5] Another point is that any discourse on how to manage the decline of fossil fuels has to fit with the growing framework of international, regional, national and subnational laws, policies and regulations on mitigating and adapting to climate change, notably via the UNFCCC. Just as the science of climate change is accepted, it should no longer be acceptable for research to discuss fossil fuels without proper

[5] The following websites provide detailed and authoritative information on climate change science and the legal and governance frameworks at the international, regional, national and sub-national level: see United Nations Climate Change (https://unfccc.int/); United Nations Environment Programme (https://www.unenvironment.org/); World Meteorological Organization (https://public.wmo.int/en); Intergovernmental Panel on Climate Change (http://www.ipcc.ch); Nongovernmental International Panel on Climate Change (http://climatechangereconsidered.org/); Yale program on Climate Change Communication (https://climatecommunication.yale.edu/); Committee on Climate Change (https://www.theccc.org.uk/); 350 (https://350.org); C40 Cities (https://www.c40.org/); NASA Global Climate Change (https://climate.nasa.gov/scientific-consensus/).

consideration of the impact of fossil fuel use on addressing climate change in efforts to transition to a sustainable low carbon energy future. This is highlighted by McGlade and Elkin (2015: 187, emphasis added):

> Our results suggest that, globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves *should remain unused* from 2010 to 2050 in order to meet the target of 2°C… Our results show that policy makers' instincts to exploit rapidly and completely their territorial fossil fuels are, in aggregate, inconsistent with their commitments to this temperature limit.

Simply put, the exigency of climate change must act as a boundary of what is *acceptable*: there has to be a connection between climate constraints and restrictions on fossil fuel supply and use. This does not mean that we have censored the chapter contributions; in order to provide a suitably authoritative account, this book includes chapters with, at times, very different views.

3 Outline of the Book

The book consists of four parts, of which Part I contains four chapters providing an introduction to the book and Part IV, comprising two chapters, provides an epilogue with overarching conclusions and thoughts on how to manage the decline of fossil fuels. The rest of the book (Parts II and III) consists of eighteen chapters setting out these issues in more detail.

Chapter 1 sets out the context and aims of the book. In Chap. 2, Emeritus Professor David Elliott looks at the increasingly polarised debate around fossil fuel abatement and renewables in terms of whether both approaches represent strategic conflicts or tactical complementaries. While coal use is being challenged around the world, renewable energy is accelerating ahead and those who back the latter strongly often feel that any talk of finding ways to reduce the impact of continuing to use fossil fuel risks deflecting or slowing the growth of renewables. However, it is still the case that fossil fuels remain the dominant energy suppliers, and they will be so for some while. In which case, if carbon emission reduction is seen as urgent, then clean-up options are also urgent, if only perhaps as an interim measure. This chapter looks at some of the key options for abating emissions from the combustion of fossil fuel, focussing on the various types of carbon capture, their potentials and problems and possible conflicts or complementarities with renewables. While the prospects for carbon capture do not look good at present, it is argued that some of the technologies may have an interim role, but that is set in the context of diminishing reliance on fossil fuel.

Chapter 3 reopens the debate on the merits of nuclear power as an option to replace fossil fuels. In this chapter, Dr Paul Dorfman acknowledges mounting recognition over the speed and pace of the low carbon energy transition needed to mitigate climate change, and that nuclear power has been reframed as a response to the threat of global heating. However, at the heart of this assumption are differing views on how to apply foresight, precaution and responsibility in the context of the relative economics of nuclear, the uncertain role of nuclear in combating climate change, the possibility of catastrophic accidents, the consequences of those accidents, and whether there exists a place for nuclear within the swiftly expanding renewable economy. This is because, in the journey to manage the decline of fossil fuels, not all low carbon technologies may prove equally viable. Indeed, nuclear seems far less benign, far more expensive, and more carbon intensive than other options. Hence, nuclear, it is argued here, will struggle to compete with the technological, economic and security advances and advantages of the coming renewable revolution. So, in bidding a long goodbye to coal, we may also be bidding adieu to nuclear, and given the associated ramping costs and risks that cling to that quintessentially late twentieth century technology, perhaps not before time.

The following chapter critically investigates the impact of intermittent renewables including wind and solar power on the market profitability and operational capacity of conventional thermal power plants through the lens of capacity remuneration mechanisms (CRMs) in European electricity markets. Chapter 4, by Dr Taner Şahin, argues that liberalisation of the EU electricity markets has produced a range of challenges with regards to ensuring generation adequacy. Energy transition, the impact of which has become increasingly felt in recent years, further complicates the issue of generation adequacy in the EU. For instance, on the one hand, the increasing role of intermittent renewable energy sources in electricity markets as the essential component of the energy transition has a profound impact on the market profitability of thermal power plants. On the other hand, it is a well-known fact that thermal power plants maintain their importance due to the high amount of flexibility they can provide, which is particularly true for gas power plants. Based on these truths, this chapter aims to reveal how CRMs may balance between energy transition and generation adequacy concerns in the EU. In this sense, this chapter chases the question of what the role of CRMs is to sustain TPPs and, hence, the energy transition.

Part II turns to issues related to how we manage (or not, as the case may be) the decline of fossil fuels. In Chap. 5, Professor Philip Andrews-Speed analyses

China's efforts to constrain its fossil fuel consumption in light of the fact that over 80% of the country's primary energy consumption is provided by fossil fuels. Over the years, and notably since 2003, the government has promulgated a series of policies intended to constrain coal consumption, promote the use of non-fossil fuels, reduce air pollution, and enhance energy efficiency. These measures include improving the efficiency of coal-fired power stations and industrial plants, switching from coal to gas, testing carbon capture and storage or use, and boosting the share of low-carbon energy sources in the power sector. These strategies have met with a high degree of success, due mainly to the rigorous application of administrative policy instruments and subsidies. The country has great potential for the further deployment of wind and solar energy, as well as scope to boost the share of natural gas. The key determinants of the pace at which China reduces its use of fossil fuels in absolute terms are two-fold. First is the rate of economic growth. Coal has long been the swing fuel and an increase in economic growth has always boosted coal consumption. The second key variable is the mix of market and administrative policy instruments deployed. Whilst the continued introduction of market forces into the energy sector may be welcome on purely economic grounds, it is not evident that they will be effective at enhancing efficiency or reducing emissions for as long as the major energy producing and consuming enterprises remain in state hands.

Chapter 6 critically questions the role of government in managing the decline of fossil fuels in a fossil fuel intensive economy, given issues of financial interdependency and state ownership across the fossil fuel chain. Using the Netherlands as a case study to answer this question, Dr Sem Oxenaar and Mr Rick Bosman note that to prevent dangerous climate change a majority of remaining fossil fuel reserves need to stay in the ground. This requires a transition towards a low-carbon energy system. For this transition to succeed specific attention should not only be given to building-up the desired low-carbon system, but also to breaking down and phasing out the old fossil fuel-based aspects of the energy system. The Netherlands, a fossil fuel intensive economy with a historically strong fossil fuel-based energy regime, provides an interesting case for the study of such a fossil fuel phase-out. Despite a long history of policy making aimed at increasing adoption of renewable energy, the Netherlands ranked 2nd last in the EU with 6% renewable energy in 2017. This has been attributed to the strong independencies between the Dutch government and the fossil fuel industry. Mapping the financial interdependencies between the Dutch government and the fossil fuel industry, this chapter discusses its implications for the possibility of a managed decline of fossil fuels. It was found that fossil fuel related activities form an important source of revenue for the Dutch national government and the government was found to be tightly interwoven with the fossil fuel system, with ownership and financial relations found in all segments of the fossil fuel value chain, from production and exploration to use and R&D, and at the local, regional, as well as national levels of government. Through state owned enterprises the government, to some extent, itself makes up a large part of the industry. This raises questions regarding the role of government in managing the 'decline' of an industry and under what conditions a fossil fuel phase out can occur.

Dr Gokce Mete, Ms Wairimu Karanja and Ms Nduta Nienga look at the paradox at the heart of UK fossil fuel policy and low carbon energy transitions in Chap. 7. The UK Continental Shelf (UKCS), particularly oil and gas activities in the North Sea have been and continue to be critical for the economic development and empowerment of the region. There has been a decline of production in the North Sea, caused by several factors, including the fall in global oil prices. With this in mind, the UK Oil & Gas Authority (OGA) has adopted a strategy to maximise the economic recovery (MER) and extract as much value as possible from the fields within the UKCS. The OGA has to consider the MER strategy in the present where energy supply is expected to transition to low carbon sources. With the advent of the 2015 Paris Agreement on Climate Change, the world is moving away from fossil fuels with their higher carbon footprint. The UK therefore has to align its MER strategies with the strategies it has on energy transition, and its climate change objectives under the Paris Agreement and domestic law. This chapter examines this journey, in light of the UK's energy transition objectives, and attempts to demonstrate that it is possible for the UK to achieve its domestic MER objectives whilst collaborating with the international community and contributing meaningfully to the global energy transition.

In Chap. 8, Dr Marc Hudson critically analyses the strategies adopted by fossil fuel incumbents in Australia to undermine the energy transition and challengers to the status quo. Particularly vulnerable to climate impacts, Australia also has virtually unlimited supplies of sun and wind for renewable energy generation. However, its per capita greenhouse gas emissions are the highest in the OECD despite over 30 years of policymaker awareness of anthropogenic global warming. The cause of this seeming paradox is Australia's reliance on coal and natural gas for electricity generation. Alongside wind and solar, Australia also has superabundant quantities of black and brown coal, and natural gas. It has been the world's largest coal exporter since 1984 and has built enormous LNG export infrastructure over the last decade. Many have noted the enormous inertia in the energy system, but this inertia has to be constantly (re)-enacted and re-enforced. In order to incentivise, accelerate (or at the very least manage!) the decline of the incumbents, it is necessary to understand their current and potential defensive strategies. This chapter outlines the political, economic and cultural strategies and tactics deployed by incumbents and their proxies in their (largely successful) efforts at slowing the Australian energy transition. In addition to a practical contribution, it helps thicken our understanding of power and agency within socio-technical transitions. In the political sphere incumbents have repeatedly defeated policies around carbon pricing which could have undermined their business model and supported their competitors. They have ensured that any climate policies that were ultimately agreed contained significant caveats and loopholes which would allow 'business as normal'. Specific policies in support of renewable energy have been retarded in their development, grudgingly implemented and endlessly reviewed and changed, leading to investment droughts. Institutions created to support renewables have been de-funded, their remits changed to undermine their efficacy. Incumbents have worked to ensure that the market rules favour large, centralised fossil fuel generators, making market entry harder for decentralised and renewable sources. Economically, incumbents have worked to slow the growth of alternative sources of electricity generation. Energy-related R&D funding has been funnelled towards incumbent fossil-fuel industries, the few extant subsidies for renewables deployment attacked relentless, and pro-renewables policies repeatedly reviewed and revised. Culturally, incumbents have responded to climate change by engaging in both issue minimisation and outright denial. To do this they have created think tanks and front groups to provide a steady stream of (mis) information for journalists and cultural warriors. Similarly, they have attacked renewable energy for its purported aesthetic and wildlife impacts. For over a decade they have claimed that wind turbines are a health risk to human beings. Beyond this, they have reified 'baseload', asserting that only centralised fossil-fuel generators can provide 'energy security'. Most recently they have attempted to reframe events such as the 2016 South Australian blackout as a reason to eschew renewables.

Mr Daniel Gilbert and Ms Pooja Chatterjee, in an analysis of the Indian power sector, ask how long 'King Coal' will remain dominant. In Chap. 9, they show that the Indian power sector is highly dynamic and its destination uncertain. Clearly it is undergoing a transition, but important aspects of that change remain hidden. Coal combustion still dominates Indian electricity generation; 'King Coal' still reigns in India. But for how long? Renewable energy generation is undergoing a boom the economic certainty of which is undermined by very low pricing achieved via energy auctions. Power sector mis-governance afflicts the renewables sector and is even more pronounced in

India's coal mining and thermal energy sector. Domestic policy drivers dictate the need for greater and greater levels of electricity generation, and for cleaner air—an objective not consistent with current thermal power practice in India. International concern regarding climate change is finally finding an echo in India, and the country has undergone a remarkable transformation from climate change laggard to powerful advocate and leader. The dynamics of domestic-international Indian policy-making are analysed through the lens of India's emerging energy transition, its likely future destination, and the ability of the renewables sector to take the additional load.

The following chapter by Dr Victoria R. Nalule investigates the transition to a low carbon economy in the developing world. Focusing on Africa and Sub-Saharan Africa (SSA) in particular, Chap. 10 seeks to answer whether Africa is ready to bid farewell to fossil fuels in light of ongoing issues of energy poverty and access. The need for a global transition to a low carbon economy has gained a lot of attention in recent years following the adoption of the Paris Agreement in 2015 whose main aim is to reduce greenhouse gas emissions, thus necessitating a shift from fossil fuels to renewable energy sources. Although many developed countries especially in Europe are able to more easily shift to renewables, the question that arises is, are developing countries such as those in Africa ready for this shift? The strong correlation between economic development and energy consumption also raises the question as to how African countries can address energy poverty and access challenges while at the same time protecting the environment? Given the energy challenges and low rates of economic development in most SSA countries, this chapter addresses the decarbonising efforts in Africa highlighting the challenges and way forward.

The next chapter examines the changing international energy development paradigm and the risks and challenges facing Russia in the low carbon energy transition. Chapter 11 analyses an objective character of the shift in the key paradigm of international energy development from the perception of 'peak supply' to 'peak demand'. Through primarily coupling this shift with the climate agenda, namely the 2015 Paris Agreement (COP-21), Professor Andrey Konoplyanik argues that the preconditions of this shift refer to previous international developments, of almost half a century ago. The key reason for pushing the international energy economy towards this shift appears in the early 1970s with the radical increase in international oil prices. The following 'domino effects' of world economy adaptation to the new oil price levels and pricing mechanisms created, in a few decades, accumulated structural effects on the world economy in its shift from being 'energy-wasteful' before the 1970s to an increasing focus on 'energy-efficiency' today. And it is only based on this development with diminishment of the GDP of energy intensity worldwide that the climate agenda has added another dimension to the trend, by increasing in significance the 'carbon intensity' factor, similar to the way 'energy intensity' has been a dominant issue since the early 1970s. As the shift from an energy-wasteful to energy-efficient economy creates risks and challenges for different states due to their competitive advantages and disadvantages under 'old' and 'new' economic structures globally and nationally, the same will be the story with low-carbon development. This set of issues will be analysed in this chapter with particular attention to Russia.

In Chap. 12, Mr Stefan Bößner analyses the dual issues of agency and power in an evaluation of the role of German trade unions in the Energiewende. Although portrayed as a global success story in the deployment of renewable energy, the German energy transition is an interesting beast. While the share of renewable energies in the power sector has reached impressive dimensions, the country's emissions remain stubbornly high. One reason for this counter intuitive development is the significant role coal has played and continues to play in Germany's energy mix and in the German economy. This chapter shines a light on this continuous love affair with coal and investigates how coal has historically shaped the German economy, its energy system and even the cultural identity of coal regions. Furthermore, the chapter analyses the role of German coal stakeholders such as utilities and labour unions and investigates the agency and power those stakeholders are still able to wield in order to prop up the fossil fuel-based energy system. By doing so, this chapter offers some explanations on why tackling coal as an energy source has been so difficult in Germany.

The final chapter of Part II looks at the issue of fossil fuel decline and the rural economy with Scotland as the case study. Using the lens of socio-technical regimes and transitions, the succession of socio-technical transitions from pre-industrial largely renewable energy, through water power, coal, hydropower, oil and gas and now renewables is explored in relation to rural Scotland in Chap. 13. Emeritus Professor Bill Slee argues that it is evident that the exploitation of energy has had major impacts on rural Scotland, and these may be more important in terms of major spatial and temporal demographic and economic variations than changes in the traditional primary land-based industries. It is evident that rather than there being a switch from one regime to another, the processes of regime change are uneven and partial, with legacies of earlier regimes lingering long after for a variety of reasons. The impacts of these different regimes were formerly almost exclusively market-driven, but since nationalisation of coal and energy production and, in spite of subsequent privatisation, public policy now sits alongside markets as a major influence on rural development outcomes. The capital-intensive nature of contemporary renewable energy systems means that modest employment is created in construction and even less in maintenance and monitoring. However, where community ownership has been asserted this offers highly significant revenue streams to support rural development, and alongside landowner renewables development, helps to retain benefit streams within the rural economy.

Part III concentrates on new agendas and approaches to managing the decline of fossil fuels. In Chap. 14, Dr John Whitton and Dr Ioan Charnley-Parry examine energy governance, public participation and shale gas fracking in-order to understand if the UK is actually on the path to saying goodbye to fossil fuels or whether the country is witnessing efforts to start a new fossil fuel resurgence. The chapter discusses the promotion of shale gas as a part of a UK energy mix of renewable, fossil fuel and nuclear technologies. This seems to go against international agreements signed by the UK Government and others to reduce global greenhouse gas emissions. This chapter frames discussion in terms of 'Energy Governance' and the authors' own conceptualisation of social sustainability. However, it is also clear that all forms of electricity generation have not been without public controversy in the UK. Unconventional, shale gas or fracking seems to have been the most prominent and has highlighted a systemic and persistent issue; that of a lack of transparency and access to planning and decision-making surrounding energy developments in the UK and the lack of agency afforded to affected communities. This chapter argues that collaborating with local communities, whereby diverse local needs, experiences and expertise, and priorities are explored is more likely to lead to decisions that are socially sustainable.

Chapter 15 explores critical junctures in the US State of New York's approach to fossil fuel regulation with a focus on whether to ban or regulate hydraulic fracturing. Dr Ida Dokk Smith examines the political process leading up to the ban on hydraulic fracturing in New York State. This involved locating the early phase ending with the governor's decision to update the state's environmental review guidelines for permitting in 2008 as a critical juncture. In retrospect this was a near miss for the oil and gas industry. The decision changed the rules of the game to one where the opposition defended the status quo and gave grassroot opposition time to mobilise. The case illustrates that political feasibility of restrictive supply side climate policies is not something we can define with a predefined set of variables but is created through the political process. Furthermore, this chapter notes an increasing use of such policy measures since the ban. This suggests that the decision to ban hydraulic fracturing also marks an acceleration of the state's transition towards a renewable energy economy.

Chapter 16 by Mr Iain Wright examines the regulatory and market reform interventions necessary to switch from conventional to renewable power systems looking at the US and Russian energy markets. Measuring renewable generation deployment in terms of megawatts installed over time offers a somewhat restricted viewpoint from which to understand the interactions of technical, market, regulatory and economic factors that ultimately determine the success or failure of low carbon generation policy. This chapter examines some of the fundamental technical and economic differences between power systems comprising renewable and conventional technologies and why these necessitate economic, as well as regulatory, interventions in order to provide a viable investment environment for new capacity. Measures to mitigate the impact of capacity duplication on conventional generation, required to maintain power system reliability, are also considered in this context. The validity of this analysis is demonstrated through a review of the very different Russian and US markets, where both financial support and market reform are shown to be essential for successful deployment of renewables whereas neither, on its own, is sufficient.

Chapter 17 by Professor Dr Jale Tosun and Mr Trevelyan S. Wing looks at the diffusion of biofuel development in terms of whether or not it serves to prolong fossil fuel use or hasten the low carbon energy transition. This chapter investigates the striking similarity in biofuel development strategies within a group of fifteen significantly varied states in North and South America, Europe, Asia, and sub-Saharan Africa. How extensive are the similarities across these countries when we differentiate between 'generations' of biofuels, and how might we explain the former in terms of the biofuels-related policies observed? To address both questions, this chapter draws on policy reports and relevant scientific articles regarding the respective governments' rationales for promoting biofuels. We further show that, in each of the cases studied, biofuels were not intended as a substitute for fossil fuels but rather to complement them. At the same time, the adopted policies serve to increase the share of biofuels while reducing that of fossil fuels. While the types of biofuels promoted are not identical, decisions to adopt them have been interdependent. In the EU and US, for example, the promotion of biofuels represents an attempt to pursue multiple goals simultaneously: increase energy security, decarbonise the transportation and energy sectors, and promote agri-industrial development. As relevant markets have become structured to promote biofuels, they have in turn created an economic incentive for developing countries in particular to embrace biofuels accordingly. In this vein, the policy decisions made by more affluent countries clearly affect the policy decisions of less affluent ones, with the aforementioned incentive structure explaining the similarities observed.

Chapter 18 by Dr Cassandra Star investigates how we can re-write and thus re-make the future through transition movements and dismantling the environment-economy dichotomy. Rapid changes in social, economic and environmental circumstances necessitate transitions to reconfigured social, economic and environment futures. The move to a low carbon future will be no different; fundamentally different social, economic and environmental futures will emerge. As global adaptation to climate change dominates, different potential paths will be evident, each representing transition to a different potential low carbon future. This chapter argues that the current political debates about transitions to a low-carbon future are dominated by economic considerations, rather than environmental ones, reflecting the entrenched environment-economy dichotomy evident in the politics of nature liberal democracies and the modern state. Economic elites thus govern these discussions, failing to engage those whose futures are most at stake in the transition to a low-carbon future. Not surprisingly, these debates then also fail to engage with questions about *just* transitions, ignoring the equity and redistributive impacts of economic transformation. Despite this, major economic change offers the opportunity to re-write societal structures. In contrast to denialist and green capitalism discourses, transition movements have arisen, focussed on the idea of a just transition to a low-carbon, improved economic and environmental future for all. These movements are located at a number of key intersections that seek to unravel the environment-economy dichotomy inherent in contemporary capitalism. These include local food systems, small scale and alternative energy economies, sustainable communities and housing. Thus, current debates about transition to a low-carbon future represent a battle between competing futures globally. The outcome will transform global economic relations, global material flows and the current structures of power and economic flourishing.

Mr Tedd Moya Mose and Mr Mohammed Hazrati explore the concept of energy justice in Chap. 19 and ask whether energy justice in the fossil fuel industry is a paradox? Globally, attempts to reverse the anthropogenic effects of climate change have led to burgeoning scholarship on 'energy justice'. Energy Justice focuses on: (1) mitigating injustices associated with energy systems, (2) fairly distributing both the burdens and benefits of energy systems, and (3) having impartial and representative decision-making. Using notions such as recognition, procedural, distribution, and restorative justice, it informs energy system stakeholders to provide equitable energy services to all.

Currently, there are some inherent injustices (such as climate change) that are associated with the fossil fuel-based energy system. These distinctive injustices make the transition away from fossil fuels inevitable. However, the global energy mix suggests that fossil fuels will still have a significant role in the future. There is, therefore, a gap between the desired low-carbon future and present realities. This disparity is evinced by the exclusion or absence of key actors (the fossil fuel industry) in energy justice strategies. This chapter examines how energy justice principles can be applied to the fossil fuel industry even as the transition to more sustainable energy sources is pursued. It advances two key themes: First, how energy justice may balance the energy trilemma in the fossil fuel industry. Second, it proposes the immediate application of energy justice principles to the fossil fuel industry.

Chapter 20 by Dr Alex Lenferna looks at the issue of fossil fuel welfare versus the climate. A predominant framing within much climate literature is that the cause of climate change is free market capitalism, a perspective perhaps most prominently found in Naomi Klein's capitalism versus the climate framing. This chapter, using a range of international case studies, demonstrates how rather than the working of the 'free' market underpinning the climate crisis, instead fossil fuel subsidies, government protection and favourable policies prop up the fossil fuel industry against competition and drive much of the climate crisis. Instead of free market capitalism versus the climate, we have an extensive regime of fossil fuel welfare versus the climate. As such, it is argued here that even proponents of free market capitalism should be opposed to the current fossil fuel welfare regime. The chapter then discusses how we could create a more prosperous low carbon future at a lower cost than how much we currently subsidise fossil fuels. Studies show that by redirecting the welfare we give to the fossil fuel industry to a more socially and ecologically just future, we could greatly improve human and ecological welfare and meet the Paris Climate Agreement target of keeping warming to 1.5°C.

The next chapter turns to the issue of energy storage. Chapter 21 sets out perspectives on an energy system following the decline in fossil use and the role of energy storage. As Dr Andrew Fredrick Crossland argues, since the dawn of the industrial revolution our economies, our development and our psyche have been inherently linked to an addiction to carbon based fuels. Whilst they last, these fossil fuels can be consumed at the time and point of need—a concept called dispatchability. Low carbon sources, whether nuclear or weather dependent are often cited as being non dispatchable and so not always available when needed. Low cost, high density and easily deployable energy storage is one of a suite of technologies which could add the flexibility needed to help match the generation of low carbon energy to consumption. This chapter explores the ways in which energy storage can provide that flexibility. It considers storage in many of its forms, from fast responding batteries through to large pumped storage facilities and electric vehicles. There is a special focus on electricity systems through proposing a future 'electrical energy storage mix'. The chapter also provides a critical assessment of energy storage to provide near complete decarbonisation of homes, commercial buildings and islands through a series of case studies. This informs what storage can, and cannot achieve, in the context of abating fossil fuel.

Dr Keith Baker explores the implications of decarbonising the heat sector in Scotland. Chapter 22 revisits previous arguments that the Scottish Government is facing a perfect storm as it attempts to decarbonise heat supplies over the coming decades, with the aim to revisit the issue to question whether such warnings are too alarmist. This chapter sets out how the development of renewable and low carbon heat supplies could contribute to managing the decline of fossil fuels by providing alternative ways of meeting demand for one of our most basic needs, as well as contributing to other environmental, social and economic goals. Expanding on existing issues, particularly technology changes such as the adoption of electric vehicles and the growth of the hydrogen economy, the chapter also revisits the issue of the need for strategic planning and long-term planning and investment in infrastructure and finds that the latest proposals and policies to emerge from the Scottish Government have done little or nothing to address these needs, and indeed fall far short of them. As a result, revisiting the evidence has served to expand on how and why the threat of a perfect storm is now more real than ever.

Part IV contains the final two chapters which together provide an epilogue to the book. Alluding to the title of the book, Chap. 23 by Dr Geoffrey Wood, drawing on the findings of the chapters, asks the following questions: are we witnessing the decline of fossil fuels in our time, and will it be a '*Long Goodbye*' or more revolutionary in its decline? Paradoxically, given the stark warnings about the dangers of climate change, are we instead witnesses to a '*Long Hello*' as we continue down the road of high carbon energy use and indeed growth via new fossil fuel technologies and fuel sources? Chapter 24 by Dr Keith Baker and Dr Geoffrey Wood provides concluding thoughts on the urgency and need to manage the decline of fossil fuels as we transition to a low carbon energy future.

References

BP. 2013. BP Energy Outlook 2030 Shows Increasing Impact of Unconventional Oil and Gas on Global Energy Markets, January 15, 2013. https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-energy-outlook-2030-shows-increasing-impact-of-unconventional-oil-and-gas-on-global-energy-markets.html.

BP. 2018. BP Statistical Review of World Energy, 67th ed., June 2018. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf.

Climate Council. 2019. 11 Countries Leading the Charge on Renewable Energy, January 13, 2019. https://www.climatecouncil.org.au/11-countries-leading-the-charge-on-renewable-energy/.

Energy Transitions Commission. 2019. Home. http://www.energy-transitions.org/.

European Union (EU). 2017. EU Energy in Figures: Statistical Pocketbook 2017. https://ec.europa.eu/energy/sites/ener/files/documents/pocketbook_energy_2017_web.pdf.

Global Commission on the Geopolitics of Energy Transformation. 2019. A New World: The Geopolitics of the Energy Transformation. http://www.geopoliticsofrenewables.org/Report.

Heinrich Böll Stiftung. 2018. A Managed Decline of Fossil Fuel Production: The Paris Goals Require No New Expansion and a Managed Decline of Fossil Fuel Production. https://www.boell.de/sites/default/files/radical_realism_for_climate_justice_volume_44_1.pdf.

Hölscher, K., Wittmayer, J.M. and Loorback, D. 2017. Transition Versus Transformation: What's the Difference? *Environmental Innovation and Societal Transitions* 27(June): 1–3.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf.

Intergovernmental Panel on Climate Change (IPCC). 2018. Global Warming of 1.5°C—A Special Report. https://www.ipcc.ch/sr15/.

International Renewable Energy Agency (IRENA). 2017. Renewable Power: Sharply Falling Generation Costs. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Nov/%20IRENA_Sharply_falling_costs_2017.pdf.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H. and Rehner, R. 2015. Energy Justice: A Conceptual Review. *Energy Research & Social Sciences* 11(January): 174–182.

Jolly, J. 2019. Britain Passes One Week without Coal Power for the First Time since 1882. Wednesday, May 8, 2019. https://www.theguardian.com/environment/2019/may/08/britain-passes-1-week-without-coal-power-for-first-time-since-1882.

Lazarus, M. and van Asselt, H. 2018. Fossil Fuel Supply and Climate Policy: Exploring the Road Less Taken. *Climatic Change* 150: 1–13.
McGlade, C. and Elkin, P. 2015. The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2°C. *Nature* 517: 187–190.
Mundaca, L., Ürge-Vorsatz, D. and Wilson, C. 2019. Demand-side Approaches for Limiting Global Warming to 1.5°C. *Energy Efficiency* 12(2): 343–362.
Muttitt, G. 2016. The Sky's Limit: Why the Paris Climate Goals Require a Managed Decline of Fossil Fuel Production. Oil Change International, September 22, 2016. http://priceofoil.org/2016/09/22/the-skys-limitreport.
Renewable Energy Network (REN21). 2019. Renewables 2018 Global Status Report. http://www.ren21.net/wp-content/uploads/2018/06/17-8652_GSR2018_FullReport_web_final_pdf.
United Nations Framework Convention on Climate Change (UNFCCC). 2018. The Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
Unruh, G. 2000. Understanding Carbon Lock-in. *Energy Policy* 28(12): 817–830.
van Asselt, H. and Lazarus, M. 2018. Special Edition: Fossil Fuel Supply and Climate Policy. *Climatic Change* 150(1–2): 1–129.
Vaughan, A. 2018. UK Renewable Energy Capacity Surpasses Fossil Fuels for First Time. *The Guardian*, November 6. https://www.theguardian.com/environment/2018/nov/06/uk-renewable-energy-capacity-surpasses-fossil-fuels-for-first-time.
Wood, G. 2016. Written Submission to the House of Lords Economic Affairs Committee Inquiry 'The Economics of UK Energy Policy', September 2016. http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/economic-affairs-committee/the-economics-of-uk-energy-policy/written/39645.pdf.
Wood, G. 2018. Policy Risk, Politics and Low Carbon Energy. In: Considine, J. I. and Paik, K. (Eds.) *Handbook of Energy Politics*. Cheltenham: Edward Elgar, pp. 405–434.
Wood, G. and Baker, K. (Eds.). 2017. *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Cham, Switzerland: Palgrave Macmillan.
World Energy Council (WEC). 2016. World Energy Resources 2016. https://www.worldenergy.org/wp-content/uploads/2016/10/World-Energy-Resources-Full-report-2016.10.03.pdf.

2

Carbon Capture and Renewables: Strategic Conflicts or Tactical Complementarities

David Elliott

1 Introduction

Carbon capture and storage (CCS), the main focus of this chapter, is sometimes seen as a key technical fix allowing for the continued combustion of fossil fuels in power stations. This, however, is set in a context where coal use is being challenged around the world, while renewable energy use is accelerating ahead. Those who back the latter may often feel that any talk of finding ways to reduce the impact of continuing to use fossil fuel risks deflecting or slowing the growth of renewables and the more efficient use of energy.

It is certainly the case that fossil fuel interests want to stay in the game as long as possible and they will see ameliorative clean-up options as a way to extract as much value as possible from the major investments that they have made in the past. Some may also see emission clean-up technology as more viable than renewable energy technology, with the latter sometimes being depicted as being far-off and even utopian. We hear less of that view nowadays, with renewables supplying around 25% of global (and UK) electricity, but it is still the case that fossil fuels remain the dominant power suppliers globally, and they will be so for some while. In which case, if carbon emission reduction is seen as urgent, then clean-up options are also urgent, if only perhaps as an interim measure.

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This chapter looks at some of the key options for abating emissions from the combustion of fossil fuels, focussing on the various types of carbon capture, their potentials and problems and also looking at possible conflicts or complementarities with renewables, in the context of diminishing reliance on fossil fuel. Improving the efficiency with which the energy from fossil fuels is produced and used is also important, since that can reduce carbon emissions per kWh produced and/or used, but the main focus in what follows is carbon capture, which has been seen as a way to deal with the emissions *once produced*, with potentially wide-scale applications and implications (GCCSI, 2017).

Quite apart from the technical and economic issues explored below, the carbon capture approach has its limitations. Although 'air capture' (i.e. direct from the atmosphere) might play a role, carbon capture at the exhaust level is not practical for the carbon dioxide (CO_2) emissions from burning fossil fuels in cars, trucks, buses and aircraft. Moreover, carbon capture, wherever applied, does not deal with impacts from the use of fossil fuels other than CO_2 production, such as the social and ecological impacts and risks of coal mining, oil and gas extraction and the transport of these fuels. In addition, and crucially, there are the other environmental and health impacts of burning fossil fuels, with air quality being a key issue. Although some of the acid gas and particulate emissions from the use of fossil fuels in power plants and industry may be removed as part of, or in conjunction with, some carbon capture processes, that is incidental to carbon capture. Its main focus is CO_2, so as to allow for continued fossil fuel combustion with fewer climate impacts.

2 Carbon Capture Options for Power Plants and Industry

While some see the various clean-up/ameliorative options as potential rivals to renewables, deflecting support from them, some of these options may complement rather than undermine renewables, so that conflicts might be reduced somewhat. For example, while Carbon Capture and Storage might be seen as just a way to allow for the continued use of fossil fuel, its initial development for that purpose might also be seen as an interim step toward the adoption of 'negative carbon' Biomass with Carbon Capture and Storage (BECCS). It is also argued that fossil plants with CCS can play a role in balancing the variable output from renewables. So, it is claimed, renewables *need* fossil CCS for backup. As we shall see, it may also be the case that CCS and other carbon capture techniques may need renewables to provide carbon free energy to power them. So, there are possible synergies.

Leaving those arguments aside for now, there is the more general issue of whether CCS, or indeed BECCS, is needed, or viable on a large scale, with some seeing CCS as likely to be too expensive and risky. The technological basics are relatively straight forward. Carbon Capture and Storage involves the capture of the CO_2 gas produced from the combustion of fossil fuels in power plants or industrial plants, via chemical absorption and then release, with the CO_2 gas being pumped in compressed form along pipes for storage under pressure in empty undersea oil and natural gas wells or other geological strata. It is sometimes claimed that CCS can reduce emissions from the use of fossil fuel in power plants by up to 90%, although in practice its overall efficiency may be more like 60–70%, partly since the various CCS processes use energy and supplying this using fossil fuels adds more CO_2 emissions.

In the power plant context, the overall efficiency and cost of CCS will depend on whether it is a coal or gas fired plant (oil-fired power plants are now rare) and on whether a pre- or post-combustion capture approach is used. The latter approach is easier, and the necessary equipment can in theory be retrofitted to any suitable existing plants, but for coal plants, pre-combustion capture (involving an initial gasification stage) may be more efficient and can provide a source of hydrogen, although it is less developed and currently costlier. Enhanced Oxyfuel combustion (in an oxygen rich environment) offers another also less developed route, with the concentration of the CO_2 that is produced being higher and more easily captured (CCSA, 2018). Unabated coal plants produce more CO_2/kWh than gas plants, so inevitably they have been the initial focus for CCS, but as coal use diminishes, gas CCS may become more important.

Whichever route is followed, clearly CCS will push up the cost of energy supply since extensive extra systems have to be built, perhaps adding up to 50% to the overall capital cost of the plant. In the retrofit context, it involves building a new clean-up plant alongside the existing power plant. Overall plant energy conversion efficiency can fall by around 10%, and water use/kWh may increase by up to 4 times, compared to a plant without CCS (Tzimas, 2011). Transmission of the captured CO_2 also adds to the overall cost: pipework has to be built and energy has to be used for pumping and compression. Storage adds further costs and is at present the most uncertain of all the costs, since it depends on the location [CUT]—given that there are few full-scale CCS projects as yet, most of the costs are uncertain. Nevertheless, the International Energy Association (IEA) GHG project has claimed, perhaps rather optimistically, that "*the cost of avoiding CO_2 emissions is 40–60 US$/tonne of CO_2 (depending on the type of plant and where the CO_2 is stored), which is comparable to other means of achieving large reductions in emissions*" (IEA, 2018).

Permanent storage of the captured CO_2 is obviously the aim, but some doubt whether it can be achieved reliably over very long periods, depending on the location and its geology. Oil and natural gas were trapped underground in strata safely for eons, until the artesian well cap was breached for extraction, so it is argued that refilling them with compressed CO_2 should not involve extra risks. However, the space available in such wells is relatively limited. While, in something of a symmetrical exchange, they might in theory be sufficient to take most of the CO_2 from oil and gas burning, we also have large amounts of CO_2 from coal burning to deal with, and the coal did not come from these sites. There are other geological options, with, in theory, more space available, such as open aquifers, but they may be less secure. Accidental rupture and rapid release of large volumes of gas could be very dangerous, particularly if the storage sites were on land rather than offshore. When cool, CO_2 is heavier than air, so it could produce a suffocating blanket of gas. That actually happened at a Lake in Cameroon in 1986, when a large cloud of trapped, naturally produced, CO_2 was released, killing over 1,700 people (Atlas Obscura, 2013).

However, all being well, in the CCS context, it is thought that some of the stored gas may, in time, bond with rocks and perhaps form new solid calcium carbonate deposits. Some experience with geological injection and storage has been gained from Enhanced Oil Recovery using injected gas, although very long-term storage would involve new challenges (DECC, 2015).

Despite the technical complexity and reliability issues, CCS has been seen as vital, with the IEA arguing that, globally, "*CCS could deliver 13% of the cumulative emissions reductions needed by 2050 to limit the global increase in temperature to 2°C (IEA 2DS)*" (ETI, 2017). There was also some urgency, with Oxford Prof. Myles Allen arguing that "*early investment in carbon dioxide disposal is crucial because most of the cheapest options, like underground storage, will take decades to develop and gain public acceptance*" (Allen, 2016: 684).

BECCS too has attracted interest (Gough and Vaughan, 2015). Burning biomass can be (roughly) carbon *neutral*, since the carbon had previously been absorbed from the air by plant growth, but if the CO_2 produced is then captured, the process can be overall carbon *negative*. The ETI has estimated that BECCS could supply around 10% of UK power along with substantial net carbon reduction, servicing around 10 GW of power generation and other industrial sources fitted with CCS (Gammer and Newton-Cross, 2016). However, views differ on the need for and viability of BECCS (Carbon Brief, 2016; Lowe, 2016). Clearly its progress depends on the development of bioenergy technology and the necessary sustainable biomass sources. Its wide scale use implies a very significant increase in biomass production and land use (Newton-Cross and Evans, 2015), although with major uncertainties about the scale needed and the ultimate global potential (Wiltshire and Davies-Barnard, 2015). Crucially, it also depends on the success of CCS. That has not so far been spectacular—See Box 2.1.

Box 2.1: Progress on carbon capture

Some coal CCS prototypes were tested in Germany and elsewhere, and two large coal CCS projects are running in North America, but further progress on CCS has been slow, with concerns about the cost leading the UK to halt its £1 billion CCS competition in 2015. It had taken a while for suitable schemes to come forward, with the White Rose project at the Drax site near Selby, Yorkshire, and a Shell project at Peterhead in Scotland eventually being selected as candidates. But with the funding gone, in 2015, both projects were abandoned. This outcome was seen by some as very unfortunate (ETI 2015; Oxburgh 2016). Explaining the decision, then Prime Minister David Cameron said, "*You spend £1 bn on carbon capture and storage, you get some carbon capture and storage capacity and it would cost you, at the current estimate, something like £170 per megawatt-hour. That compares with unabated gas costing £65, onshore wind perhaps as costing £70 and nuclear costing, say, £90* […] *Governing is about making decisions, and it seemed to me that the right decision was to say that we would not go ahead with the £1 bn, because that is £1 bn that we can spend on other capital investment projects, including energy projects such as making progress on energy storage or modular reactors*" (Cameron, 2016).

The UK cut back has been replicated elsewhere, with, subsequently, work on the flagship US Kemper coal CCS project being halted after massive cost overruns (to US$7.5 billion); it has been converted to a gas plant (Fehrenbacher, 2017). Norway, already a CCS pioneer with its enhanced oil recovery technology, has also cut its CCS funding (Cuff, 2017a). Some project work continues around the world, and the Global CCS Institute lists 17 CCS-type projects running worldwide (GCCSI, 2018). However, most are gas processing and chemical plants, not power plants. Although more CCS projects of various types are planned, at present, there are just two working coal CCS power projects, the US$1 billion Petra Nova project in the USA (EIA, 2017) and the US $1.5 billion Boundary Dam project in Canada (IEA, 2015). They both use the captured CO_2 for Enhanced Oil Recovery (so CO_2 will be produced again when the oil is burnt). Despite some interests in Australia and China, large coal CCS projects seem unlikely to prosper, with there being criticisms of the existing projects in terms of the high cost, high energy use (up to 25% of the plants output) and low final carbon capture rates (Homes à Court, 2017). In time, new CCS technology may of course reduce costs, for example for the capture phase (Papageorgiou, 2014; Ondrey, 2015; Novek et al., 2016), but, for the moment, the overall message seems to be that, with costs seen as high, it is 'game over' for fossil CCS as a major option for power plants (Simon, 2017).

The prospects for BECCS are therefore also unclear. It also has opponents. As with CCS, not all the carbon can be captured. Moreover, those concerned about the environmental impact of the increased use of biomass are inevitably unhappy with BECCS. They see it as having major land-use impacts and as undermining important carbon sinks (Biofuelwatch, 2015). In a report on biomass for Chatham House, Duncan Brack says: "*The reliance on BECCS of so many of the climate mitigation scenarios reviewed by the IPCC* [International Panel on Climate Change] *is of major concern, potentially distracting attention from other mitigation options and encouraging decision makers to lock themselves into high-carbon options in the short term on the assumption that the emissions thus generated can be compensated for in the long term*" (Brack, 2017: 12). A similar view was adopted by a recent critical study from the Netherlands Environmental Assessment Agency and the Copernicus Institute (van Vuuren et al., 2018), claiming that BECCS was not vital, and arguing for more of a focus on other mitigation options, with its lead author saying that that it was 'unfortunate' that work to date on meeting the Paris '1.5C' target has been so dominated by BECCS (Evans, 2018).

Nevertheless, there is still support for BECCS and for CCS. Indeed, the UK government's advisory Committee on Climate Change (CCC) insist that BECCS is vital to meet climate targets (CCC, 2018). A small BECCS pilot project is underway at the Drax plant in Yorkshire (Drax, 2018), although that has no storage as yet. Moreover, there are also plans for a larger prototype CCS fossil gas project in Scotland 'in the mid-2020s', with offshore storage (Keane, 2018).

Clearly, as indicated in Box 2.1, the cost of CCS has proved to be a key factor in its slow progress. So, for the moment the prospects for CCS, and therefore also BECCS, look limited, with other decarbonisation options being seen as possibly more attractive. Auke Lont, the CEO of Norwegian power grid operator Statnett, has said that, given the emergence of renewables at a cost "*below seven euro cent per kilowatt hour… there is no room for carbon capture and storage in the power sector. In the power sector, the game is over because other technologies have surpassed CCS*" (Simon, 2017).

While there is still some pressure for adding CCS to new gas plants, it seems unlikely that anyone would now build a new coal plant with CCS. These setbacks will not be welcomed by those who see CCS as the best way to secure a future for fossil fuel, or by those who believe CCS and/or BECCS are vital to cope with or reduce carbon emissions. For example, the UK Energy and Climate Change Select Committee has claimed that, without CCS, the UK "*will not remain on the least-cost path to our statutory decarbonisation*" (ECCSC, 2016: 3).

Most recent energy scenarios have included CCS as a key element, and some have included BECCS, although the emphasis has varied. For example, the IPCC have backed both CCS and BECCS strongly (IPCC, 2017), and while the IEA, in a joint report with the International Renewable Energy Association (IRENA) sees CCS as important for the power and industrial sectors, IRENA see CCS as being deployed exclusively in the industry sector, with renewables dominating the mix: they do not look at BECCS (IRENA, 2017).

Certainly, CCS can be used for carbon emissions from industrial processes, as well as from power plants. It may be that this will be the main focus, since, some argue, CCS may offer an easier way to decarbonise industrial activities than replacing their use of fossil fuel with renewables. That is debatable: it depends on the industrial process. In some (e.g. fertiliser and chemical production), CO_2 generation is inherent to the manufacturing process, and CCS might be attractive, although, if, rather than CCS, carbon capture and *utilisation* is adopted (i.e. CCU), then some industries may find it possible to develop valuable new products, including synthetic fuels. For example, the captured CO_2 could be processed chemically with hydrogen to make methane gas or liquid methanol. In general, CCU does look more economically attractive than CCS, given that it offers the potential for new valuable products, and it may be that, unlike CCS, it will prosper in some sectors. However, as is explored later, synfuel production using captured CO_2 requires a source of hydrogen (e.g. from electrolysis of water, or steam reformation of fossil gas), and overall CCU does still rely on complex capture and conversion technology. So, there may be efficiency and cost limitations to synfuel production (Dimitriou et al., 2015). Moreover, the combustion of synfuels will produce CO_2, so, unlike with CCS, there are no carbon gains with this CCU option, and the adoption of this approach for biomass plants, i.e. 'BECCU' (Biomass Carbon Capture and Utilisation), would lose the negative carbon benefits of BECCS.

3 Air Capture

While the debate continues over which is the best way to deal with emissions directly from power plants and industry, there are also other more general carbon capture options under development, based [of CUT] on capturing CO_2 from the air. Unlike conventional CCS, they have the advantage of also being able to deal indirectly with the CO_2 added to the atmosphere from other sources, such as cars and aircraft, where CCS is not possible.

In so-called Direct Air Capture, air is sucked through large filters in towers containing an absorbent such as liquid sodium hydroxide, which reacts with the CO_2 to give sodium carbonate. Solid *adsorbent* options also exist. The captured CO_2 is then released and stored or used as a source of carbon for chemical or synfuel production, with, in either case, the sorbent being recycled for reuse (Lackner, 2015). The CO_2 storage route offers a *carbon negative* option, in the sense that it pulls CO_2 directly out the atmosphere. However, unlike BECCS, it would not generate energy, indeed it would use energy. The synfuel approach (sometimes labelled 'Air to Fuel', or A2F), does offer an energy output, but since burning synfuels would generate CO_2, the overall process would no longer be carbon negative. Moreover, as with fossil CCU and BECCU, hydrogen, as well as more energy, would be required to make the synfuel.

There are other significant issues, whichever route is taken. At around 0.04%, the proportion of CO_2 in air is very much lower than in the exhausts of power plants or industrial flue pipes, so the air capture approach has a fundamental problem compared with conventional CCS or CCU. It needs to handle large volumes of air in large scale units and more energy is needed to achieve similar capture rates. Whereas fossil plant CCU can make use of amine absorbents for CO_2 capture, they are expensive, and to deal with the much larger volumes of gas that have to be processed to get at the small CO_2 component, for Air capture, lower cost but less efficient chemical extraction options have to be used, requiring more energy. Nevertheless, some see Air capture as viable. Indeed, Bill Gates has supported the development of one such system (Crew, 2015). It seems a long shot, although it may yet prosper, especially in its CCU/synfuel variant, as may some other developments in the atmospheric CCU/A2F field (ACS, 2015).

The main advantage air capture has over conventional power plant/industrial CCS/CCU, apart from being potentially carbon negative (if the CO_2 is stored), is that it can be done anywhere. It does not have to be at or near a power plant. It does take space, but it is argued that, since it is much more efficient at carbon capture than plant photosynthesis, it will take much less room/tonne of carbon than BECCS and would require perhaps 1,000 times less area/tonne carbon [, CUT] than growing trees to capture CO_2. Costs remain high, at around \$600/tonne C, but there are hopes of getting down to \$100 or less. However, that has to be compared to the \$60–90/tonne C claimed by some fossil plant CCS projects and the \$30/tonne evidently achieved by one Indian CCU project (Cuff, 2018).

Moreover, given that it does requires energy, it seems unlikely to be cheaper to extract CO_2 from air than to avoid its production by using renewable energy powered devices, such as wind turbines, directly for power. Although renewable energy sources can be used to power the air capture process, it is not clear if that is the best use for their output in carbon saving terms. Hopefully that will become clearer after current trials in Switzerland and Canada, with talk of using PV solar or other renewables for the energy input

(Peters, 2017; Vidal, 2018). There is also a unit in Iceland, working on a geothermal energy site (Cuff, 2017b).

Apart from the more obvious and low costs carbon negative route of planting trees, there are other sometimes exotic global geoengineering-based air capture ideas, though they may have large scale, unpredictable, possibly even irreversible environmental impacts, e.g. seeding the seas with ferric compounds to increase greenhouse gas retention (Keller et al., 2014). By contrast, although it takes space, planting more trees seems so much easier and less risky, although trees do die and rot and can catch fire, so releasing the CO_2 they have absorbed and stored back into the air. Nevertheless, reforestation is an attractive carbon sink option, and also offers other environmental benefits. More subtly, changes in farming practices including 'no till' soil management, can have major GHG absorption implications. So, may biochar production: it can improve soil quality and CO_2 retention. Perhaps we do not need artificial 'Air Capture' trees.

However, if significant amounts of carbon are to be captured biologically, the scale of operation required, as with BECCS, would have to be vast. A recent review of all the negative emission technologies (NETs) by the European Academies' Science Advisory Council (EASAC) concluded that they had 'limited realistic potential' to halt increases in the concentration of greenhouse gases in the air at the scale envisioned in the Intergovernmental Panel on Climate Change scenarios (EASAC, 2018).

It looked at reforestation, afforestation, improved soil management techniques, ocean fertilisation and BECCS, as well as enhanced geo-chemical absorption and direct air capture and carbon storage. Given the technical and land use limitations, it suggested that these NETs, even taken together, did not have the potential to deliver carbon removals at the 12 Gigaton Carbon p.a. scale and at the rate of deployment envisaged as needed by the IPCC to help reach the carbon reduction targets agreed in the Paris climate accord. The maximum potential of the biological options as identified in the literature by EASAC was around 10 GT p.a., with reforestation/afforestation possibly offering 3.3 GT p.a., BECCS 3.3 GT p.a., and better land use management 2–3 GT p.a., while ocean fertilisation offered under 1 GT p.a. However, all of these estimates were seen as very optimistic. For example, on trees, it noted that, sadly, it was hard enough just fighting deforestation.

Direct Air Capture came out at possibly slightly ahead at 3.3 + GT p.a. but overall, in its press release for the EASAC report mentioned above, EASAC (2018: 1) warned that "*scenarios and projections that suggest that NETs future contribution to CDR* [CO_2 removal] *that allow Paris targets to be* *met thus appear optimistic on the basis of current knowledge and should not form the basis of developing, analysing, and comparing scenarios of longer-term energy pathways for the EU… Relying on NETs to compensate for failures to adequately mitigate emissions may have serious implications for future generation*".

So, there are major limits. Certainly, unless carried out on a vast scale, air capture on its own, by whatever means, is unlikely to be sufficient to deal with the scale of our historic, current and projected carbon emissions, some of which have gone into, or will go into, the seas (Cao and Caldeira, 2010). Extracting CO_2 from the oceans might be an option, and some have suggested that fuel could be made from it (Morgan, 2013). The concentration of CO_2 in the oceans is higher than in the air, so it might be worth it. The extracted CO_2 would of course be replenished in the seawater by CO_2 absorbed from the air, but it has been suggested that schemes that consume/remove and sequester excess ocean CO_2 can effectively address both excess ocean and air CO_2, sidestepping the need for direct air CO_2 capture. That may be true, but the cycle will have to be continually repeated, whatever technology and CO_2 location is used, if CO_2 is still being added to the air from combustion.

That is fundamental problem with carbon capture. If more CO_2 is being added, there will be an endless need for energy-using technical fixes for carbon reduction, with potentially diminishing returns. Air capture or CO_2 extraction from the oceans also seem to offer few collateral benefits for renewables. There might possibly be a supporting role for renewables in providing the necessary energy, but it is not clear if that is the best use for them, and, more generally, there is a risk that support for carbon capture may detract from support for renewables and energy efficiency. In terms of the NETs the EASAC review looked at, including air capture, one of its authors commented "*negative emissions technologies are very interesting, but they are not an alternative to deep and rapid emissions reductions. These remain the safest and most reliable option that we have*" (Shepherd, 2018). The implication being that we should focus on the latter, and not be sidelined or deflected.

4 The Hydrogen Option

While air capture has limits, and direct power plant and industrial carbon capture may have problems, there is a hybrid CCS/CCU approach to enabling the continued use of fossil fuel that may hold some promise. That is the idea of converting fossil gas into hydrogen by steam reformation, with CCS added to reduce emissions. Earlier above, mention was made of the use of hydrogen to convert CO_2 captured from power plants or industry into synfuels such as methane. That was also an option for air and ocean captured CO_2. However, in this new CCU/CCS variant, fossil methane is the *starting* point. It is converted to hydrogen which is then used as a fuel, the extracted CO_2 being stored, making the overall process (apart from the energy needed to run it) near carbon neutral, since the hydrogen when burnt does not generate CO_2. This approach might have potential for complementarity with renewables, as the technology develops, by opening the way up the use of fully 'green' renewable hydrogen as a fuel, with no fossil gas or CCS then being needed.

Certainly, once produced, hydrogen offers a clean and flexible new energy vector. When burnt in air it just produces water (and some trace NOx) and it can be used as a replacement for fossil gas in many contexts, including home heating. Mixtures of hydrogen and fossil gas are already in use in the USA and Germany and elsewhere, but it is also possible to go for 100% hydrogen if modern plastic pipe work is available. In theory, depending on how it is sourced, with hydrogen as a fuel, there should be significant reductions in emission compared with the continued direct use of fossil gas e.g. for domestic heating and cooking. By contrast with the current UK plan for decarbonisation of home heating by installing electric heat pumps, it would avoid the need to replace domestic gas-using appliances. The existing cookers and gas fired boilers would only need small adjustments to run on hydrogen. Moreover, rather than stressing the power grid further, the existing gas mains can continue to be used, with only minor upgrades. In the UK, the gas main carries around 4 times more energy than the power grid, so a full switch over to electric heating would be very difficult to achieve. There are already plans for the injection of hydrogen, or syngases derived from it, into to the UK gas grid (Ambrose, 2018) and also a 100% hydrogen gas main switch-over proposal, the H21 scheme in the city of Leeds, as well as the Cadent project in the Liverpool/Manchester area—see Box 2.2. The estimated capital cost are relatively high e.g. around £2bn for H21, with £139 million p.a. operating costs, and £600m for Cadent, with operating costs near £60m p.a. But projects like this may offer a new way forward, given the attractions of hydrogen as a fuel for heating.

Box 2.2: Hydrogen options

The Leeds H21 project involves a switch over to 100% hydrogen, made by steam reformation of fossil gas, injected in the Leeds gas mains, with CCS taking care of the CO_2 produced in the conversion process. It is seen as pioneering showcase effort that, if successful, could be replicated in other cities (H21, 2016). In parallel, a somewhat smaller Cadent Liverpool-Manchester Hydrogen Cluster project, still at concept stage, aims initially to supply a high hydrogen mix just to selected industrial gas customers, although possibly also, in a blended mix with fossil gas, to domestic consumers. The CO_2 produced from steam reformation process would be captured and then stored in depleted gas wells in Liverpool Bay (Cadent, 2017).

As noted above, in term of gas use, the change-over to 100% hydrogen would require some system adjustment. Hydrogen at high concentrations can cause embrittlement of metal pipework, with the potential for leaks or ruptures. Fortunately, most of the UKs old iron gas mains pipework has been upgrade with plastic pipes, but not all. That programme would have be extended to every house. The replacement of burners in appliances is also not a trivial operation. In the UK, before the advent of North Sea Gas, appliances used to run on Town Gas made from coal, which included a high proportion of hydrogen along with methane and carbon monoxide. For the change-over to North Sea gas (which is mostly methane), starting the late 1960s, the burner jets of all appliances had to be replaced, in a national refit programme. It took about 10 years to complete the full change over, which cost around £100m. In effect, that process would have to be reversed to allow appliances to run on 100% hydrogen.

There are also some more fundamental efficiency issues. There will be losses associated with the multi-stage gas conversion and CCS process, including some energy use for the reformation process so that, for the H21 system, is was estimated that 47% more gas will be needed to get the same heat output as would be obtained if the gas was used directly for heating. So, the net emissions saved, even with CCS, would only be 59% compared with the conventional gas route (Lowes, 2016).

There are also non-fossil options for the systems like this. Some biogas, produced by Anaerobic Digestion (AD) of farm and other wastes, might also be used as a feedstock for hydrogen production via steam reformation, rather than just fossil gas (Sattar et al., 2014). If 100% green biogas was used, the process would be carbon negative with CCS, or carbon neutral without it. But if we have green biogas, then why go for conversion to hydrogen? Why not just inject AD-derived bio-methane into the gas mains? Or perhaps go for a blended mixture. That is what is being done elsewhere. Blending may be necessary since there is unlikely to be sufficient biogas available, even if also using food waste, to meet heat demand, although low-carbon syn-gases from industrial sources might be used (Abbess, 2015).

Alternatively, there is electrolysis route. Hydrogen gas can be produced directly by the electrolysis of water, using electricity from wind and PV solar plants. In addition to use for heating, as in the H21 concept, it can be used for balancing variable renewables. Hydrogen, made using surplus renewable electricity, generated when availability is high and/or power demand is low, would be stored, ready to be used to make electricity again, in a gas turbine or fuel cell, when wind and/or solar availability is low, and/or demand for it is high (Sky, 2014). This idea is under rapid development in Germany and elsewhere (Ogleby, 2018), with CCU variants also being developed. For example, in some cases, the hydrogen gas is converted to methane, using CO_2 captured from power plants, and then injected into the gas main for heating (Windgas, 2017). Hydrogen or methane can also be used a vehicle fuel. Clearly this overall 'Power to Gas' (P2G) concept can yield a range of useful fuel options (Hydrogenics, 2018).

However, the Power-to-Gas conversion process is at present relative inefficient (50–60% typically) making the resultant green hydrogen or methane expensive. According to French company Engie, which is looking to shift to green hydrogen production and distribution, steam reforming of hydrocarbons, which accounts for 95% of hydrogen produced today, costs about €2/kilo, compared to €6/kilo for electrolysis (De Clercq, 2017). But, as electrolysis technology improves, with the advent of high efficiency PEM (Proton-Exchange Membrane) cells like the one developed by UK company ITM Power, costs are falling. ITM Power claim that their PEM cell has an overall efficiency, with heat recovery, of 86% and it has been wining orders for its technology in Germany as well as the UK (ITM Power, 2018). They clearly see this as the way ahead (Cooley, 2017). The Power to Gas hydrogen option will be looked at as part of the H21 programme, although given its still relatively high cost, it is not seen as likely to be a major option for now, even though it would avoid having to use CCS. However, that may change as the costs of renewables and P2G fall and the cost of fossil gas rises (Richard, 2018). Certainly, recent studies have suggested that this approach merits attention (Institution of Mechanical Engineers (IMechE), IMechE, 2018; Butera et al., 2018).

Both of these projects are focused on hydrogen production via steam reformation, so that CCS is vital if this approach is to expand. However, whether, as one commentator suggested "*the prospect of a hydrogen-based energy system could prove a clinching argument for the development of CCS*", remains to be seen (Keay, 2018: 20).

As noted in Box 2.2, for the moment, most hydrogen is produced using steam reformation of fossil fuel, but, since it can also be produced using renewables, some see the focus on fossil-derived hydrogen, sometimes called 'brown hydrogen', as a diversion from a switch to genuinely 'green hydrogen' produced using renewables sources (with no need for CCS), including synthetic green gases from Power to Gas (P2G) conversion. Others however see it, and the development of industrial sources of hydrogen, as a possible step on the way to the adoption of renewable hydrogen, by establishing greener gas in the heating market, ready for later replacement by fully green biogas and P2G syngas, when and if that becomes available on a wide scale (Abbess, 2015). The point being that, at present, as noted in Box 2.2, hydrogen from steam reformation is much more economically viable than (renewable) power-to-gas conversion. While that may be true for now, it ignores the emission issues associated with using fossil gas and adding CCS would push up the cost. P2G avoids that. But, as noted in Box 2.2, for the moment that route is not being looked at seriously for the Leeds H21 project.

That highlights a key strategic problem that emerges in this and other ostensibly interim fossil fuel-use cases. If we continue to focus on the cheaper short-term ameliorative options, the longer-term renewable options will always remain longer-term: they have to be promoted before they can (hopefully) become competitive. That is what has been done to some extent with renewables so far, often in the face of objections from those seeking support for ameliorative measures for fossil fuel use, which usually look cheaper and easier in the short term. Renewables have nevertheless succeeded in moving out of niches into the mainstream, aided by subsidies which have helped them to become increasingly competitive. Carbon capture, in its various forms, has so far not been able the achieve that, and, given its problems, it may never do so. However, to the extent that some of the carbon capture technologies may have a useful interim role to play in emission reduction and possibly also synfuel production, a more coherent approach than just leaving them to sink or swim may be needed.

5 Optimal Carbon Reduction

In his 'Systems Thinking for Geoengineering Policy', Robert Chris, looking very broadly at geoengineering possibilities, argues that we should promote approaches to dealing with climate change that are "*robust against the widest range of plausible futures, rather than optimal only for the most likely*" (Chris, 2015). Certainly, options should not be foreclosed, and a strategic framework is arguably needed which identifies an acceptable role for carbon capture in its various forms, with full attention being given the likely impacts (Williamson, 2016), but attention also being given to the strategic carbon reduction issues and options. It is clear, even to those looking to near 100% renewable scenarios, backed by the wide adoption of energy efficiency measures, that fossil fuel use will continue for some while, particularly in the heating, industrial and transport sectors. While ideas are emerging for dealing with these sectors using renewable sources, they will take time to develop fully, so some fossil fuels may have to continue to take the strain for a while. In which case they need to be cleaned up.

In a context of diminishing reliance on fossil fuel, that should not be a problem in principle, even for the most devoted renewable energy enthusiasts, but the key issue will be the timeframe—how fast can renewables be expanded, how much can energy efficiency help slow and ideally reduce demand? What do we need to do to get emission down rapidly, so as keep temperature rises below danger levels? And, not incidentally, what role might nuclear power play in all this?

There are a range of scenarios addressing issues like this. For example, the IRENA scenario mentioned earlier (part of a joint report with the IEA), has renewables supplying 82% of global electricity by 2050, and 65% of global primary energy by then, with CCS only in limited industrial use (IRENA, 2017). More radically, there is no fossil, nuclear or CCS use in the scenario by Jacobson et al. at Stanford University, which looks to wind, water and solar power supplying 100% of *all energy* by 2050 globally (Jacobson et al., 2017). That may sound ambitious, but with several countries already obtaining over 50% of their electricity from renewables, hydro included, projections like this no longer look impossible, although their realisation in practice will depend on a range political and economic factors.

However, it remains to be seen if that will be enough political support to meet the ambitious carbon reduction goals agreed in 2016 in Paris (Victor et al., 2017). Certainly, a recent study led by the Potsdam Institute claimed that conventional mitigation measures would not be sufficient and what it labelled as Carbon Dioxide Removal technologies (CDR) were vital to meet the 1.5°C Paris climate target without overshoot (Kriegler et al., 2018). For the foreseeable future, fossil fuels are thus likely to play a key role, with, in some countries, that probably being unavoidable for some while. For example, 90% of South Africa's electricity comes from coal plants. It will take time to change that (Cook and Elliott, 2018). In which case, although change must be a high priority, we need to decide which interim ameliorative technologies to adopt in parallel.

As we have seen there are many options, depending on the context. Gas plant CCS may prove viable in some locations, but there will be diminishing returns from building major new long-lived coal CCS plants, and CCS is perhaps anyway more suited to the chemical and industrial sector, which we will need into the future. CCU, creating value from captured carbon by making synfuels from it, also has its attractions, even if burning them will produce CO_2.

Not all the options for carbon reduction from fossil fuel use involve CCS or CCU. In all sectors, fossil fuel use can be improved to reduce energy waste and in the industrial sector there are many opportunities to improve process efficiency and make better use of byproducts. In the power sector, Combined Heat and Power (CHP)/cogen, linked to district heating networks and heat stores, can be a relatively low carbon option. By using some of the otherwise wasted heat, CHP gets much better value from the fossil fuel input than non-CHP plant, with overall energy conversion efficiencies of up to 80%, and with biomass feedstock net carbon emissions could be almost zero. Moreover, while it may be hard (and uneconomic) to operate CCS and CCU systems flexibly, CHP plants, linked to heat stores, can be used flexibly to balance the variable output from renewables, by varying the ratio of heat to power output. If there is too much green power on the grid, the CHP plant can produce mostly heat. If demand for that is low, it can be stored. If green power availability is low, the proportion of CHP plant power output can be raised, and if there is still demand for heat it can be drawn from the heat store. Although CHP does need a nearby heat load to serve, in the power sector, it can be a flexible and valuable transitional option for heat as well as power, complimenting renewables, and capable of reducing emissions/kWh significantly, without the need for CCS. CHP can also be used in the industrial context, meeting power and heat demand directly and reducing emissions.

The UK governments new Industrial Strategy (HMG, 2017) seeks to decarbonise all sectors, including manufacturing, and, although CHP gets some backing, along with district heating, CCS and CCU have been promoted as options within its Clean Growth Strategy. £20m has been provided for a 'Carbon Capture Usage and Storage' (CCUS) demonstration programme. The aim is to "*demonstrate international leadership in carbon capture usage and storage (CCUS), by collaborating with global partners and investing up to £100m in leading edge CCUS and industrial innovation to drive down costs*" (BEIS, 2017).

The appeal of CCS and CCU in the industrial context is clear. As noted earlier, one of the arguments for CCS/CCU is that it will be hard to provide non-fossil energy for some energy intensive industries. However, in addition to its role in the wider power sector, CHP could play a role here too, and it is also possible to use renewables to power some of these processes. So, we may not need much fossil CCS for industrial heat and power. See Box 2.3 for some examples.

Box 2.3: Renewables for industrial emission reduction—avoiding CCS

Renewable sources can be used to power product manufacture, but there are also some options in the primary material sector, e.g. steel and aluminium production. Given that these activities can be very energy intensive, there is a major incentive to cut energy use so as to reduce emissions and also cut costs. Improved process efficiency is the obvious first step.

However, in some cases, renewables are also now an attractive way to cut industrial costs and emissions. As the percentage of renewable input to the grid system grows, grid power can supply the power needed with increasingly low carbon content. But it is also possible to do this directly, using power generated on site or nearby. This has already been done with some so-called 'merchant power' projects, for example at Ford's engine plant in Dagenham in East London, which has installed a series of large wind turbines. Ideas are now also emerging for primary industry. For example, the Lochaber Aluminium smelter near Fort William in Scotland is to get power from a wind farm with up to 54 wind turbines at nearby Glenshero, which may also supply Liberty's Dalzell steel mill in Motherwell. That could make some of the steel for the turbines (Musaddique, 2017).

Steel production is also being revamped by the GFG Alliance, which has a 'Greensteel strategy' which aims to cut the amount of raw steel imported to the UK, by dramatically increasing the amount of scrap steel which is recycled, and also to use renewables for its processing. It plans to use electric arc furnaces part-powered by renewable energy to melt scrap steel so that it can be reused, a process which is more environmentally friendly than primary steel-making in a blast furnace powered by coal. It is claimed that "*Greensteel, made using renewable energy, has only one tenth of the carbon footprint of blast furnace production*" (Tovey, 2017).

There are some other similar plans. For example, a forge in Sheffield aims to use biogas, supplied from an anaerobic digester fed with food and other waste from a nearby waste recycling centre (REM, 2017). Further afield, an Australian steel works is to have 1 GW of renewable power supply, including 680 MW of PV, with 100 MW of batteries, 100 MW of demand response and 120 MW of pumped hydro storage (Climate Action, 2017).

Large scale, zero carbon, primary material production and manufacturing using renewable energy may still be some way off, but, in principle, it seems credible, with, in some locations, direct use being made of Concentrated Solar Power plants, which, with overnight on-site heat storage, can deliver power 24/7 (Jacobson et al., 2017).

It has yet to be proven, but, as the grid-linked renewable energy system develops, with storage and other backup, the industrial use of renewables may make more sense environmentally and economically than fossil or biomass CCS, although it remains unclear whether CCU might still have an advantage, depending on the industry. In some cases (e.g. chemicals and fertilisers), CO_2 production may be unavoidable. In the main however, renewables can provide carbon free energy for most of industry. Some see a role for new types of nuclear plant in the industrial context, possibly run in CHP mode, supplying heat, power and perhaps also generating hydrogen, although, quite apart from nuclear safety and security issues, the economics of nuclear power remain uncertain (Elliott, 2017). If hydrogen is to be produced, and/or heat supplied, renewables may offer a better route.

There are other views on the role of fossil fuel and its CO_2 implications, some of them quite radical. For example, Oxford Prof. Peter Edwards and Cambridge Prof. Sir John Meurig Thomas have argued that:

> *fossil fuels should not be burnt (with the attendant CO_2 emissions)* [but should be] *catalytically decomposed to generate high-purity hydrogen as a renewable-energy carrier. The other product of this non-combustion route is solid carbon—not the climate-damaging gaseous CO_2—a useful starting material for other products. The bottom line is that fossil fuels have great potential in producing "green hydrogen" without CO_2 emissions. CO_2 mitigation technologies can therefore be applied to the continued use of fossil fuels.* (Edwards and Thomas, 2017)

That is certainly an interesting perspective, a new role for carbon, avoiding the need for CO_2 capture, and opening up the possibility of a whole new patterns of fuel production and industrial interaction, though still based on fossil resource use. As we have seen, fossil gas is already used to make hydrogen economically, and CCU could widen that, but it is not clear what the economics of this more comprehensive non-combustion approach would be. Some energy would be needed to drive the conversion process. As in the case of Air Capture, renewables might play a support role in providing that. To that extent, it might be seen as offering some synergistic support for renewables, although, arguably, it would be better to use renewables directly. Moreover, if synfuels like hydrogen are seen as valuable, then the Power-to-Gas renewables approach may deliver them with fewer problems. For example, although combustion-related emissions are avoided in the proposed fossil resource conversion process, it will presumably generate waste products, some of which may be hazardous. In addition, the environmental problems of fossil resource extraction and transport would remain. Moreover, and crucially, the fossil resource is limited: so, unlike renewables, it is not a long-term option.

For the moment we are faced with the urgent need to deal with the emissions that are being produced from combustion, while seeking to reduce or avoid them longer term. The non-combustion carbon-use model outlined above offers no direct help with the first of these requirement (it does not capture CO_2), although, if it proved to be technically and economically viable, it could offer a medium-term carbon emission-free synfuel option. However, given the extraction and waste issues and the energy costs, it might be seen as an unwelcome and risky rival to full commitment to renewables, with limited collateral or synergistic benefits, and also no long-term future.

Although, as we have seen, some of the other options also have limits, some of them are more developed. Even so, they may be also face limits. As noted earlier, EASAC drew together some estimates of the maximum possible potential, based on its literature review, on the Negative Emission Technologies. It suggested that a 10 GT (Gigatons) p.a. total estimate for negative carbon technologies (which excludes fossil CCS) might still be high, and was anyway well short of 12 GT p.a. envisaged as needed by the IPCC, although EASAC did note an estimate of up to 4 or more GT p.a. for fossil CCS (EASAC, 2018). Table 2.1 draws the main EASAC maximum estimates together. Some of the main issues, as identified above, are also noted.

There is broadly comparable data for some of the above in a recent PNAS study and in a linked review by Climate Brief, although wider ranges are offered, the latter argued that the natural carbon sink options could possibly store as much carbon as BECCS (Hausfather, 2018).

EASAC did not look at possible *utilisation* options, just at Negative Emission Technologies, although it did include fossil CCS, which, as shown in Table 2.1, had the highest score. Looking more widely, Table 2.2 presents a summary of all the options looked at above, including CCU, indicating, in rough terms, their potential for carbon reduction.

As can be seen, while trees and other bio-sequestration measures may do well, in line with Table 2.1, it is suggested that net carbon emissions from fossil fuel energy production with CCS might be attractive in tonnage terms. CCU may not be fully carbon neutral, but it is low carbon (depending on the efficiency of the overall CCS process), but net emissions are raised with CCU, assuming synfuels are produced and burnt, although the net CO_2 produced would be offset if green hydrogen is used to make them. Similarly, with synfuels from BECCU. Although the biomass feed stock for this is near net carbon neutral, using fossil hydrogen to make synfuel for combustion would mean the overall process would not even be carbon neutral. But it could be if

Table 2.1 Maximum estimates for carbon saving

	Gigatons of carbon captured per annum	Key issues
Fossil carbon and capture	4+	Not carbon negative
Air capture and storage	3.3+	Low CO_2 concentrations in air so more energy needed
Bio-sequestration—Forest planting	3.3	Low photosynthesis efficiency so need space and time
Biomass with CCS	3.3	Low photosynthesis efficiency so need space and time
Improved land/soil management	2.5	Slow organic processes
Ocean fertilisation	1	Potential eco-impacts

Source: Adapted from EASAC (2018)

green hydrogen was used. By contrast, BECCS is carbon negative, taking CO_2 out of the carbon cycle. That is also true in the case of Air Capture with storage, although no energy is produced, while some energy is required, whereas with Air capture and synfuel production, some net energy is produced, although hydrogen is needed and the overall A2F process is then not carbon negative, since the synfuels are burnt. The use of green hydrogen, and also renewables for the operating energy, would however improve the A2F situation- it might then be near carbon neutral.

In the case of renewable Power to Gas (P2G) hydrogen production (not covered by EASAC), direct carbon production is zero, and it is not raised if synfuels are produced (using CO_2) and then burnt, since this carbon has been captured. The fossil gas to hydrogen (H21) route looked at above would have higher conversion losses than simple fossil CCS, but the carbon saved might still be similar. Certainly, burning the hydrogen produced would not generate CO_2. That is also the case with the non-combustion route, and that process itself has no carbon emissions, although it needs energy.

For the sake of completeness, Table 2.2 also includes energy efficiency, which can cut energy use dramatically and so avoid carbon emissions. CHP is

Table 2.2 Summary of carbon reduction measure impacts and requirements

Technology	Net carbon emissions	Requirements
Trees and bio-capture	Negative/Cyclic	Land area/land management, time!
Fossil CCS	Low	Large-scale indefinite CO_2 storage
Fossil CCU to synfuel	High/Medium[a]	Hydrogen to make synfuel
BECCS	Negative	Large biomass area and storage volumes
BECCU to synfuels	Low/Zero[a]	Hydrogen to make synfuel
Air capture + storage	Low/Negative[a]	Energy for the process and large storage
Air capture to synfuel (A2F)	Low/Zero[a]	Energy and Hydrogen to make synfuel
Fossil gas to H2 with CCS	Low	Large-scale indefinite CO_2 storage, energy
Renewable P2G—H2	Zero	Renewable energy input
Renewable P2G—CH4	Zero	Renewable energy input, plus CO_2
Non-combustion route to H2	Zero/Low	Energy to drive the process
Fossil CHP (but low C heat)	High/Medium	Nearby heat demand
Biomass CHP (+ low C heat)	Low/Zero	Nearby heat demand
Renewables (wind/solar)	Zero	Some land use implications
Nuclear	Low	Fuel production, waste storage, security
Efficient use of energy	Negative	Willingness to invest to save!

[a]If green hydrogen/renewables for power is used

also included. That can have low carbon emissions, depending on the fuel used. Direct use of renewables like wind or solar would of course have zero direct carbon emissions. Finally, there is the nuclear option. It too has zero direct CO_2 emissions, but unlike renewables such as wind and solar, it requires energy to make its fuel and the carbon debt associated with that is likely to increase as the uranium resource is depleted and lower grade ores have to be used. It also has many other problematic issues and uncertain prospects (Elliott, 2017).

Note that all these emission estimates are in absolute terms, indicating very roughly how much CO_2 output might result from each option, including from any subsequent synfuel use and from the energy used for the capture process. 'High' is this context means the same as, or similar to, conventional unabated fossil generation. Strictly, Air Capture with storage falls outside of this ranking (it does not produce any energy), but its carbon impacts can still be usefully compared. A more substantial assessment would cover the relative costs (hard to do at this early stage) and also include the carbon implications of the energy embedded in the technologies, and of any grid balancing required or provided. The latter is important since, in the short term, fossil fueled plants will play a role in balancing variable renewables, but longer term there are better ways to balance renewables, without having to extract, transport and burn fossil fuels, and then store CO_2 forever (Elliott, 2016).

6 Conclusion

It can be argued that the best way to store carbon is to leave it in the ground, and to look elsewhere for energy. Certainly, the various carbon capture ideas discussed above, trees and soil capture apart, do seem a little inelegant in engineering terms. Fossil CCS is a classic 'end of pipe' technical fix, capturing a waste gas and pumping it underground in the hope that will stay there, all so that we can continue to use fossil fuels for a while longer, while avoiding some of their emission impacts. Fossil CCU may be more commercially attractive, in that it offers new syn-fuel options, and avoids the problems of storage, although it is in its infancy, and it is not a negative carbon option or even carbon neutral, since the fossil synfuel is burnt. Direct Air Capture is also in its infancy, and it too is an energy hungry process, but, with carbon storage and using renewables for power, it could still be negative carbon, or, without storage, a source of synfuel, though their combustion would generate CO_2. BECCS and BECCU would avoid direct fossil fuel use, and BECCS could deliver negative carbon, although at the cost of extensive land use for biomass production and the need for CO_2 storage space. Finally, the non-combustion approach to fossil resource use avoids CO_2 production, but relies on a limited fossil resource, with their still being potential environmental impacts from their extraction, transport and use.

By contrast, in general, renewables, and in some contexts CHP, along with energy efficiency, arguably look much better bets, both now and in the long-term, in energy, environmental and cost terms. The renewable resource is very large and will last indefinitely, the impacts from using it are generally low and costs are falling rapidly. Energy efficiency improvements are also usually very cost effective and are vital to cut emissions. They also complement renewables: lowering energy demand makes it easier to meet it with renewables.

In this context, and given the problems discussed above, the potential for carbon capture of whatever sort looks a little limited at present. Even adopting what some might see as an optimistic assessment of CCS, the UK government recently projected that there might only be 1 GW of fossil CCS in place in the UK by 2035, as opposed to 45 GW of renewables (BEIS, 2018). Deployment of CCS elsewhere might be more extensive, and perhaps should be, for example given the continued use of coal in some Asian countries. However, China is now trying to cut back rapidly on coal use (CER, 2018) and, interestingly, a critical report on CCS for the Global Warming Policy Foundation, which is not usually a fan of renewables, claimed that "*for China, investment in the transmission grid to permit wind generation in the west to be managed jointly with hydro plants in the rest of the country is a far cheaper way of reducing CO_2 emissions in the next 10–15 years than retrofitting existing coal plants with CCS or building new coal plants with CCS*" (Hughes, 2017: x).

However, new CCU/low carbon technologies are emerging which might offer new, less costly, opportunities in some locations (Gorder, 2018; Sulleyman, 2018) and certainly enthusiasm for carbon capture still remains. For example, the Global CCS Institute says that "*CCS is needed because the amount of fossil fuels we burn continues to rise*" and looks to massive expansion of fossil CCS. Nevertheless, it insists that "*CCS is not a 'front' for the coal or wider fossil fuel industry*", suggesting that CCS can be run in parallel with renewables, and indeed that it will help to balance variable renewables, although it also quotes some very low estimates for potential renewable contributions (GCCSI, 2017: 12).

While energy futures can be debated, as we have seen, in strategic terms, it may be wise to be cautious about the potentials quoted by enthusiasts for the various carbon reduction options. As the EASAC President warned in relation to NETs:

> *whether consciously or subconsciously, thinking that technology will come to the rescue if we fail to sufficiently mitigate may be an attractive vision. If such technologies are seen as a potential fail-safe or backup measure, they could influence priorities on shorter-term mitigation strategies, since the promise of future cost-effective removal technologies is politically more appealing than engaging in rapid and deep mitigation policies now. Placing an unrealistic expectation on such technologies could thus have irreversibly damaging consequences on future generations in the event of them failing to deliver. This would be a moral hazard which would be the antithesis of sustainable development.* (EASAC, 2018: iv)

Nevertheless, the EASAC did accept that some of the technologies "*can make some contributions to remove CO_2 from the atmosphere even now, while research, development and demonstration may allow others to make a limited future contribution*" (EASAC, 2018: iv).

Given this more limited role for NETs and carbon capture, some of the potential conflicts with renewables might be avoided. However, that clearly depends on the strategic context. If fundamental conflicts over energy strategy persist, fuelled by climate denial and/or doubts about renewables, then it will be hard to pursue a rational interim mix of renewables and abated fossil plants, or other carbon reduction options. Support for all the latter may be resisted by green zealots as 'backsliding', and opportunities for synergies, productive co-operation and complementarity may be lost. That has been the case at times with gas plants used for balancing variable renewables. Although there are other grid balancing options (Elliott, 2016), some fossil gas plants will be needed for some while, even though, longer term, they may be able to use biogas or P2G syngas. Similarly, for CHP, it can offer significant benefits including grid balancing, even if, initially, it uses fossil fuel.

In the interim, in the context of a limited short to medium term role for carbon capture and exit from carbon, strategic issues will emerge. For example, would the limited role for carbon capture provide a sufficient base to develop CCS for BECCS? Moreover, *should* BECCS be developed, given its land use and other limitations? In the context of a decreasing role for fossil fuel, BECCS would no longer be in danger of providing a 'fig leaf' for continued fossil fuel use, so the debate might be less fraught. However, its outcome is still unclear. The same might be said for Direct Air Capture: it would no longer be seen as compensating for continued *long-term* fossil fuel use. So, some might see Air Capture as playing a limited role in the short to medium term. However, whether it would be seen as viable on a significant scale as a longer-term post-carbon clean-up option is unclear. That issue, and the interim role of carbon capture and utilisation, would be open for debate, which would be eased if there was no risk of supporting the continued use of fossil fuels. But by contrast, the non-combustion approach to fossil resource use would seem to retain the potential for at least some continued conflict: although it would not produce CO_2, essentially it would underpin the arguably unsustainable use of relatively scarce resources, while possibly inhibiting the full and rapid development of renewables.

There are some interesting parallels in all this with the situation in relation to the long-term disposal of nuclear waste. All agree that what we have produced so far has to go somewhere, but many environmentalists are unwilling to support proposals for repositories while more waste is planned to be produced in new nuclear plants. Nuclear waste and CO_2 are very different, but the strategic conflict is the same: the solutions are hard to discuss while more is being produced, with no end in sight. However, as far as fossil fuels are concerned, the end is in sight, and some say that is also the case for nuclear. But until these endpoints are ascertained and confirmed, we can accept negotiations over what to do next will be difficult.

Hopefully that situation can be resolved. In the case of CO_2, that will be important, since some fossil fuel use will continue for a while. For some 'greens', perhaps understandably, having anything to do with fossil fuel will remain an anathema, but if we are to move successfully to a sustainable future, some way to deal with residual, interim CO_2 production from them will have to be found. That is also the case for some non-energy industrial CO_2 production, which may be hard to avoid. Moreover, although they may be overstated, there may be at least some potential strategic synergies between carbon capture and renewables. As we have seen CCS might open up some non-fossil options, like BECCS or green hydrogen use. Meanwhile, renewables may be needed to provide zero carbon energy to run CCS/CCU systems, while renewables may need CCS to enable fossil fuelled plants to pay an interim role in balancing variable renewables. So 'greens' may have to learn to 'deal with the devil with a long spoon', at least for a while. In a context where renewables are dominant and expanding, and a diminishing reliance on fossil fuel has been agreed, that may be less threatening to them.

References

Abbess, J. 2015. *Renewable Gas*. Basingstoke: Palgrave Macmillan.

ACS. 2015. "Diamonds from the Sky" Approach Turns CO_2 into Valuable Products. *American Chemical Society News*, August 19. https://www.acs.org/content/acs/en/pressroom/newsreleases/2015/august/CO_2.html.

Allen, M. 2016. Drivers of Peak Warming in a Consumption-maximizing World. *Nature Climate Change* 6: 684–686. http://www.nature.com/articles/nclimate2977.

Ambrose, J. 2018. Energy Networks Prepare to Blend Hydrogen into the Gas Grid for the First Time. *The Telegraph*, January 6. http://www.telegraph.co.uk/business/2018/01/06/hydrogen/.

Atlas Obscura. 2013. Lake Nyos Suffocated Over 1,746 People in a Single Night. *Slate*. http://www.slate.com/blogs/atlas_obscura/2013/07/26/lake_nyos_killed_1746_when_it_released_a_huge_pocket_of_CO_2.html.

BEIS. 2017. Clean Growth Strategy. UK Department of Business, Energy and Industrial Strategy, London. http://www.gov.uk/government/publications/clean-growth-strategy.

BEIS. 2018. Updated Energy and Emissions Projections 2017. UK Department of Business, Energy and Industrial Strategy, London. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/671187/Updated_energy_and_emissions_projections_2017.pdf.

Biofuelwatch. 2015. Last-ditch Climate Option, or Wishful Thinking? Biofuelwatch BECCS report. http://www.biofuelwatch.org.uk/2015/beccs-report/.

Brack, D. 2017. *Woody Biomass for Power and Heat Impacts on the Global Climate*. London: Chatham Horse. http://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2017-02-23-woody-biomass-global-climate-brack-embargoed.pdf.

Butera, G., Jensen, S.H. and Claussen, L. R. 2018. A Novel System for Large-scale Storage of Electricity as Synthetic Natural Gas Using Reversible Pressurized Solid Oxide Cells. *Energy* 166(1): 738–754. https://www.sciencedirect.com/science/article/pii/S0360544218320693?via%3Dihub.

Cadent. 2017. The Liverpool-Manchester Hydrogen Cluster: A Low Cost Deliverable Project, Report by Progressive Energy Ltd August. https://cadentgas.com/about-us/innovation/projects/liverpool-manchester-hydrogen-cluster.

Cameron, D. 2016. House of Commons Liaison Committee, Oral Evidence: Evidence from the Prime Minister. Q 79-Q83, HC 712, January 12. http://data.parliament.uk/WrittenEvidence/CommitteeEvidence.svc/EvidenceDocument/liaison/evidence-from-the-prime-minister-12-january-2016/oral/26761.htm.

Cao, L. and Caldeira, K. 2010. Atmospheric Carbon Dioxide Removal: Long-term Consequences and Commitment. *Environmental Research Letters* 5, 024011. http://iopscience.iop.org/article/10.1088/1748-9326/5/2/024011/pdf.

Carbon Brief. 2016. In-depth: Experts Assess the Feasibility of 'Negative Emissions'. Carbon Brief Review of Expert Opinions, April 12. http://www.carbonbrief.org/in-depth-experts-assess-the-feasibility-of-negative-emissions.

CCC. 2018. Biomass in a Low-Carbon Economy, Committee on Climate Change, London. http://www.theccc.org.uk/wp-content/uploads/2018/11/Biomass-in-a-low-carbon-economy-CCC-2018.pdf/.

CCSA. 2018. Carbon Capture and Storage Association Web Site. http://www.ccsassociation.org/what-is-ccs/.

CER. 2018. China Slashing Coal Power Capacity at Rapid Rate. *China Economic Review*, March 2. https://chinaeconomicreview.com/china-slashing-coal-power-capacity-at-rapid-rate/.

Chris, R. 2015. *Systems Thinking for Geoengineering Policy*. London: Routledge.

Climate Action. 2017. Australian Steelworks Aims to Unite Renewable Energy with Heavy Industry. *Climate Action*, October 31. http://www.climateactionprogramme.org/news/australian-steelworks-aims-to-unite-renewable-energy-with-heavy-industry.

Cook, T. and Elliott, D. 2018. *Renewable Energy: From Europe to Africa*. Basingstoke: Palgrave Pivot.

Cooley, G. 2017. We Need Long Term, Large-scale Energy Storage Solutions. *Medium* Blog by ITM Power CEO Graham Cooley, September 22. https://medium.com/@cH2ange/graham-cooley-we-need-long-term-large-scale-energy-storage-solutions-b30f79f11f54.

Crew, B. 2015. Scientists are Building a System That Could Turn Atmospheric CO_2 into Fuel. *Science Alert*, July 22. http://www.sciencealert.com/scientists-are-building-a-system-that-could-turn-atmospheric-CO_2-into-fuel.

Cuff, M. 2017a. Norway Proposes Major Cuts to Carbon Capture and Storage Budget. *Business Green*, October 16. http://www.businessgreen.com/bg/news/3019206/norway-slashes-carbon-capture-and-storage-budget.

Cuff, M. 2017b. Climeworks Flicks Switch on 'World First' Atmospheric Carbon Capture Plant. *Business Green*, October 11. https://www.businessgreen.com/bg/news/3019003/climeworks-flicks-switch-on-world-first-iceland-plant-sucking-and-storing-CO_2.

Cuff, M. 2018. CCS Group Captures £900,000 Government Grant. *Business Green*, February 14. http://www.businessgreen.com/bg/news/3026633/ccs-group-captures-gbp900-000-beis-grant.

DECC. 2015. Carbon Capture and Storage Knowledge Sharing: Commercial, Project Management and Lessons Learned. Department of Energy and Climate Change, London. https://www.gov.uk/government/publications/carbon-capture-and-storage-knowledge-sharing-commercial-project-management-and-lessons-learned.

De Clercq, G. 2017. Engie Plans to go Green Via Biogas and Renewable Hydrogen. *Business Insider*, December 4. http://uk.businessinsider.com/r-engie-plans-to-go-green-via-biogas-and-renewable-hydrogen-2017-12.

Dimitriou, I., García-Gutiérrez, P., Elder, R., Cuéllar-Franca, R., Azapagic, A. and Allen, R. 2015. Carbon Dioxide Utilisation for Production of Transport Fuels: Process and Economic Analysis. *Energy and Environmental Science* (6). http://pubs.rsc.org/en/content/articlelanding/2015/ee/c4ee04117h-!divAbstract.

Drax. 2018. Europe's First Bioenergy Carbon Capture and Storage Pilot Now Underway. Drax Company Press Release, November 26. https://www.sciencedirect.com/science/article/pii/S0360544218320693?via%3Dihub.

EASAC. 2018. Negative Emission Technologies: What Role in Meeting Paris Agreement Targets? European Academies' Science Advisory Council, Halle. https://easac.eu/publications/details/easac-net/.

ECCSC. 2016. Future of Carbon Capture and Storage in the UK. House of Commons Energy and Climate Change Select Committee, Second Report of Session 2015–16. https://publications.parliament.uk/pa/cm201516/cmselect/cmenergy/692/692.pdf.

Edwards, P. and Thomas, J. 2017. Letter to *The Times*, August 14.

EIA. 2017. Petra Nova is One of Two Carbon Capture and Sequestration Power Plants in the World. US Energy Information Agency Data Sheet. https://www.eia.gov/todayinenergy/detail.php?id=33552.

Elliott, D. 2016. *Balancing Green Power*. Bristol: Institute of Physics Publications.

Elliott, D. 2017. *Nuclear Power: Past, Present and Future*. Bristol: Institute of Physics Publications.

ETI. 2015. ETI Comment on the Scrapping of the £1bn CCS Commercialisation Competition. Energy Technologies Institute, November 27. http://www.eti.co.uk/news/eti-comment-on-the-scrapping-of-the-1bn-ccs-commercialisation-competition/.

ETI. 2017. Carbon Capture and Storage Needs to be Part of the UK's Future Energy System or We Will Face "Substantially Higher Costs". Energy Technologies Institute Article in Politics Home, April 4. https://www.politicshome.com/news/uk/energy/opinion/energy-technologies-institute/84830/carbon-capture-and-storage-needs-be-part/.

Evans, S. 2018. World Can Limit Global Warming to 1.5°C Without BECCS. *Carbon Brief*, April 13. http://www.carbonbrief.org/world-can-limit-global-warming-to-onepointfive-without-beccs.

Fehrenbacher, K. 2017. Carbon Capture Suffers a Huge Setback as Kemper Plant Suspends Work. *Greentech Media*, June 29. https://www.greentechmedia.com/articles/read/carbon-capture-suffers-a-huge-setback-as-kemper-plant-suspends-work-gs.XPab7k4.

Gammer, D. and Newton-Cross, G. 2016. The Evidence for Deploying Bioenergy with CCS (BECCS) in the UK. Energy Technologies Institute, Loughborough. http://www.eti.co.uk/insights/the-evidence-for-deploying-bioenergy-with-ccs-beccs-in-the-uk.

GCCSI. 2017. The Global Status of CCS. Global Carbon Capture and Storage Institute. http://www.globalccsinstitute.com/status.

GCCSI. 2018. Large-scale CCS Facilities, Global Carbon Capture and Storage Institute. http://www.globalccsinstitute.com/projects/large-scale-ccs-projects.

Gorder, P. 2018. A Fossil Fuel Technology that Doesn't Pollute. *Ohio State University News*, January 2. https://news.osu.edu/news/2018/01/02/a-fossil-fuel-technology-that-doesnt-pollute.

Gough, C. and Vaughan, N. 2015. Synthesising Existing Knowledge on the Feasibility of BECCS, DECC Supported Avoid Programme, Tyndall Centre for Climate Change Research, University of Manchester, Grantham Institute, Imperial College London, Walker Institute, University of Reading. http://www.avoid.uk.net/2015/07/synthesising-existing-knowledge-on-the-feasibility-of-beccs/.

Hausfather, Z. 2018. Analysis: How 'Natural Climate Solutions' Can Reduce the Need for BECCS. *Climate Brief*, May 21. http://www.carbonbrief.org/analysis-how-natural-climate-solutions-can-reduce-the-need-for-beccs.

HMG. 2017. Industrial Strategy, UK Government White Paper. http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/662541/industrial-strategy-white-paper-print-version.pdf.

Homes à Court, S. 2017. Does the Best CCS Power Station in the World Provide a Model for Australia? *Quora*, November 9. https://www.quora.com/Does-the-best-CCS-power-station-in-the-world-provide-a-model-for-Australia.

H21. 2016. H21 Leeds City Gate Team Report. Northern Gas Networks. https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf.

Hughes, G. 2017. The Bottomless Pit. Global Warming Policy Foundation, London. http://www.thegwpf.org/content/uploads/2017/06/CCS-Report.pdf.

Hydrogenics. 2018. Hydrogenics Power to Gas Entry of Their Commercial Web Site. http://www.hydrogenics.com/wp-content/uploads/power-to-gas-4pg-brochure-2012.pdf.

IEA. 2015. Integrated Carbon Capture and Storage Project at SaskPower's Boundary Dam Power Station. International Energy Agency GHG Programme Report, Cheltenham. http://ieaghg.org/docs/General_Docs/Reports/2015-06.pdf.

IEA. 2018. International Energy Agency GHG Programme. Information Sheets and Reports. http://ieaghg.org/ccs-resources/what-is-ccs.

IMechE. 2018. Energy from Gas: Taking a Whole System Approach. Institution of Mechanical Engineers, London. http://www.imeche.org/news/news-article/new-report-using-gas-grid-to-store-excess-electricity-could-boost-uk-renewables.

IPCC. 2017. Fifth Assessment Report, Intergovernmental Panel on Climate Change, Geneva. http://www.ipcc.ch/report/ar5/index.shtml.

IRENA. 2017. Perspectives for the Energy Transition: Investment Needs for a Low-carbon Energy System. International Renewable Energy Agency, Abu Dhabi, Joint report with the International Energy Agency. http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3828.

ITM Power. 2018. ITM Power Company Web Site. http://www.itm-power.com/project/rwe-power-to-gas.

Jacobson, M., Delucchi, M. Bauer, Z., Goodman, S., Chapman, W., Cameron, M., Bozonnat, C., Chobadi, L., Clonts, H., Enevoldsen, P., Erwin, J., Fobi, S., Goldstrom, O., Hennessy, E., Liu, J., Lo, J., Meyer, C., Morris, S. and Yachanin, A. 2017. 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. *Joule* 1(1): 108–121. http://www.sciencedirect.com/science/article/pii/S2542435117300120.

Keane, K. 2018. UK's First Carbon Capture and Storage Project 'Operational by Mid 2020s'. *BBC News* report, November 28. https://www.bbc.co.uk/news/uk-scotland-scotland-business-46358715

Keay, M. 2018. Decarbonisation of Heat and the Role of 'Green Gas' in the United Kingdom. Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/05/Decarbonisation-of-heat-and-the-role-of-green-gas'-in-the-United-Kingdom-NG-128.pdf.

Keller, D., Young, F. and Oschlies, A. 2014. Potential Climate Engineering Effectiveness and Side Effects During a High Carbon Dioxide-Emission Scenario. *Nature Communications* 5, No. 3304. http://www.nature.com/ncomms/2014/140225/ncomms4304/full/ncomms4304.html.

Kriegler, E., Luderer, G., Bauer, N., Baumstark, L., Fujimori, S., Popp, A, Rogelj, J., Streer, J. and van Vuuren, D. 2018. Pathways Limiting Warming to 1.5°C: A Tale of Turning Around in No Time? *Royal Society, Philosophical Transactions B*. http://rsta.royalsocietypublishing.org/content/roypta/376/2119/20160457.full.pdf.

Lackner, K. 2015. The Need for Negative Carbon Emissions and Direct Capture from Air. Power Point Presentation, Arizona State University. https://absuploads.aps.org/presentation.cfm?pid=11396.

Lowe, J. 2016. Do We Need BECCS to Avoid Dangerous Climate Change? Guest Post. *Carbon Brief*, April 14. https://www.carbonbrief.org/guest-post-do-we-need-beccs-to-avoid-dangerous-climate-change.

Lowes, R. 2016. Heat Decarbonisation Calls for Proven Technology. *UK Energy Research Centre Blog*, August 11. http://www.ukerc.ac.uk/network/network-news/heat-decarbonisation-calls-for-proven-technology.html.

Morgan, J. 2013. Zero Emission Syn-fuel from Sea Water. *Brave New Climate Blog*, January 16. https://bravenewclimate.com/2013/01/16/zero-emission-synfuel-from-seawater.

Musaddique, S. 2017. Wind Turbines Could Power Scottish Smelter and Steel Plants. *The Independent*, September 6. http://www.independent.co.uk/news/business/news/wind-turbines-scotland-smelter-steel-plants-mills-highlands-gfc-alliance-motherwell-a7932946.html.

Newton-Cross, G. and Evans, H. 2015. Delivering Greenhouse Gas Emission Savings through UK Bioenergy Value Chains. Energy Technologies Institute, Loughborough. http://www.eti.co.uk/insights/delivering-greenhouse-gas-emission-savings-through-uk-bioenergy-value-chains.

Novek, E., Shaulsky, E., Fishman, Z., Pfefferle, L. and Elimelech, M. 2016. Low-Temperature Carbon Capture Using Aqueous Ammonia and Organic Solvents. *Environmental Science & Technology Letters 3*(8): 291–296. http://pubs.acs.org/doi/abs/10.1021/acs.estlett.6b00253.

Ogleby, G. 2018. Are We a Step Closer to Achieving the 'Green Hydrogen Economy'? *Eddies News Service*, January 17. https://www.edie.net/news/6/Could-the%2D%2Dgreen-hydrogen%2D%2Deconomy-be-set-for-take-off-/.

Ondrey, G. 2015. Modified MOFS Could Cut Carbon-Capture Costs in Half. *Chemical Engineering*, April 1. http://www.chemengonline.com/modified-mofs-cut-carbon-capture-costs-half/.

Oxburgh, R. 2016. Lowest Cost Decarbonisation for the UK: The Critical Role of CCS. Report to the Secretary of State for Business, Energy and Industrial Strategy from the Parliamentary Advisory Group on Carbon Capture and Storage (CCS), September. https://gallery.mailchimp.com/4ba4a05396f0bf7eac512a9b0/files/Parliamentary_Advisory_Group_on_CCS_Final_report_VERSION_TO_PUBLISH.pdf.

Papageorgiou, N. 2014. A Cost-effective and Energy-efficient Approach to Carbon Capture. *News Mediacom EPFL*, October 13. https://actu.epfl.ch/news/a-cost-effective-and-energy-efficient-approach-to-/.

Peters, A. 2017. This Machine Just Started Sucking CO_2 Out of the Air to Save us from Climate Change. *Fast Company News*, May 31. https://www.fastcompany.com/40421871/this-machine-just-started-sucking-CO_2-out-of-the-air-to-save-us-from-climate-change.

REM. 2017. Sheffield Forge Could be the First in the UK to be Powered by Biomass and Biogas. *Renewable Energy Magazine*, November 17. http://www.renewableenergymagazine.com/biomass/sheffield-forge-could-be-the-first-in-20171117.

Richard, C. 2018. Cost of Wind-generated Hydrogen to Fall Below Natural Gas. *Wind Power Monthly*, April 28. https://www.windpowermonthly.com/article/1462904/cost-wind-generated-hydrogen-fall-below-natural-gas.

Sattar, A., Leeke, G., Hornung, A. and Wood, J. 2014. Steam Gasification of Rapeseed, Wood, Sewage Sludge and Miscanthus Biochars for the Production of a Hydrogen-rich Syngas. *Biomass and Bioenergy* 69: 276–286. http://www.sciencedirect.com/science/article/pii/S0961953414003663.

Shepherd, J. 2018. Silver Bullet to Suck CO_2 from Air and Halt Climate Change Ruled Out. *The Guardian*, February 1. http://www.theguardian.com/environment/2018/feb/01/silver-bullet-to-suck-CO_2-from-air-and-halt-climate-change-ruled-out.

Simon, F. 2017. "Game Over" for CCS, Driven Out by Cheap Renewables. *Euractiv EU News Service*, December 4. http://www.euractiv.com/section/climate-environment/news/game-over-for-ccs-driven-out-by-cheap-renewable.

Sky, J. 2014. Power-to-Gas May Solve Renewables Storage Challenge. *DW News Deutsche Welle*, July 2. http://www.dw.com/en/power-to-gas-may-solve-renewables-storage-challenge/a-17754416.

Sulleyman, A. 2018. Researchers Discover New Catalyst for Efficiently Recycling Waste Carbon Dioxide into Plastic. *The Independent*, January 16. http://www.independent.co.uk/news/science/carbon-dioxide-greenhouse-gases-plastic-polyethylene-copper-catalyst-climate-change-a8162636.html.

Tzimas, E. 2011. Sustainable or Not? Impacts and Uncertainties of Low-Carbon Energy Technologies on Water, EC JRC/AAAS Presentation. http://ec.europa.eu/dgs/jrc/downloads/jrc_aaas2011_energy_water_tzimas.pdf.

Tovey, A. 2017. GFG Alliance Reveals Strategy to Increase UK Steel Production to 5m Tonnes. *The Telegraph*, November 27. http://www.telegraph.co.uk/business/2017/11/27/gfg-alliance-reveals-strategy-increase-uk-steel-production-5m/.

van Vuuren, D., Stehfest, E., Gernaat, D., van den Berg, M., Bijl, D., Sytze de Boer, H., Daioglou, V., Doelman, J., Edelenbosch, O., Harmsen, M., Hof, A. and van Sluisveld, M. 2018. Alternative Pathways to the 1.5°C Target Reduce the Need for Negative Emission Technologies. *Nature Climate Change*. http://www.nature.com/articles/s41558-018-0119-8.

Victor, D., Akimoto, K., Kaya, Y., Yamaguchi, M., Cullenwaatrd, D. and Hepburn, C. 2017. Prove Paris Was More Than Paper Promises. *Nature*, August 1. http://www.nature.com/news/prove-paris-was-more-than-paper-promises-1.22378.

Vidal, J. 2018. How Bill Gates Aims to Clean Up the Planet. *The Observer*, February 4. https://www.theguardian.com/environment/2018/feb/04/carbon-emissions-negative-emissions-technologies-capture-storage-bill-gates.

Williamson, P. 2016. Emissions Reduction: Scrutinize CO_2 Removal Methods. *Nature* 530 (7589). http://www.nature.com/news/emissions-reduction-scrutinize-CO_2-removal-methods-1.19318.

Wiltshire, A. and Davies-Barnard, T. 2015. Planetary Limits to BECCS Negative Emissions, Avoid 2. Met Office, Grantham Institute, Tyndall Centre, Walker Institute. http://avoid-net-uk.cc.ic.ac.uk/wp-content/uploads/delightful-downloads/2015/07/Planetary-limits-to-BECCS-negative-emissions-AVOID-2_WPD2a_v1.1.pdf.

Windgas. 2017. Windgas for the Energy Transition: Uniper Lays Cornerstone for Methanation Plant. Press Release for Uniper project, *Uniper and Partners*, July 6. https://www.storeandgo.info/fileadmin/press_releases/20160705_PM_Grundstein_Falkenhagen_StoreGo_ENG.pdf.

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The Long Goodbye to the Nuclear Monument

Paul Dorfman

1 Introduction

With mounting public concern and policy recognition over the speed and pace of the low carbon energy transition needed to mitigate global climate change, nuclear power has been reframed as a partial response to the threat of global heating. Proponents suggest that nuclear provides a supply of lower carbon energy and, despite significant accidents, is acceptably safe in operation (IAEA, 1999, 2018a). However, since not all low carbon options may prove equally benign or effective in managing the decline of the fossil fuel economy, this chapter explores the relative merits of the nuclear claim.

The global energy landscape is one of differences between state and market, choices and trade-offs over supply-side, demand-side, transmission and load-balancing infrastructure (Schiellerup and Atanasiu, 2011). Although nation states may diverge in terms of cultural and industrial landscapes, public opinion, technological structures, institutions, regulatory practices and energy mixes, there remains the real possibility of evolving open and flexible frameworks in which to develop collective action on energy. This is critically important because recent reviews of the impact of climate change suggest that, over the next few decades, we will be subject to significant change in human health, welfare and environmental systems (IPCC, 2018). Key to adapting to this

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change is the transition to a low carbon and resource efficient energy economy, involving major structural changes to the way we work and live—including how we source, manage, use and conserve our energy. We need to secure clean, safe, affordable, sustainable, low carbon energy to power industry, transport, homes and businesses (Ekins et al., 2017).

The challenge of achieving this transition may involve a series of differing technically and economically viable options, including the expansion of renewable energies in all sectors, rapid growth and modernisation of electricity grids, improvements in energy efficiency, the use of modern technologies to minimise electricity consumption, rapidly enhanced storage technologies, market innovations from supply to service provision, intelligent deployment of limited gas resources, the fundamental restructuring of the built and transport environments (Stirling, 2014) and, some argue, continued reliance on nuclear power (World Nuclear Association, 2018).

Yet, at the heart of the nuclear issue are differing views on how to apply foresight, precaution and responsibility in the context of the relative economics of nuclear, the uncertain role of nuclear in combating climate change, the possibility of accidents, the consequences of those accidents, and whether there exists a place for nuclear within the swiftly expanding renewable energy evolution.

Axiomatically, the nuclear debate is complex, runs parallel to, and is often preconditioned by, differing takes on the economic internalisation of negative environmental externalities, differing interpretations on optimal energy choices to combat a warming (or heating) world, and differing attitudes to the value of precaution when considering high-impact low-probability risk (Dorfman, 2004). Current literature demonstrates that in all connected research fields, there is a history of debate and controversy that coheres to these issues and has not reached closure. In response to this knowledge deficit, and in order to understand better the nature of the controversy, a trans-disciplinary approach has been adopted here. The rationale for this approach is that the nuclear issue is an amalgam, incorporating sets of cross-cutting and interwoven phenomena, each impacting on the other. The intention is to make more visible the connections and patterns that this interplay unconsciously renders opaque. In this context, the chapter will discuss an interlocking set of issues: Nuclear construction trends; Nuclear costs; Small modular reactors; Nuclear and climate change; Nuclear liability; Nuclear probabilistic risk assessment; Radiation risk; and the relative value of nuclear in the low-carbon energy transition.

2 Nuclear Construction Trends

For nuclear to be considered a feasible option in managing the decline of the fossil fuel economy, then new reactor build should be able to be completed economically, efficiently and on-time—however, practical experience suggests otherwise.

Currently, a total of 413 nuclear reactors operate in 31 nation states. The market is dominated by five key nuclear states: the US, France, China, Russia, and South Korea—together generating 70% of the global total, with the US and France providing nearly half of all output. Globally, nuclear generates 2,500 terawatt hours (TWh), comprising 10.3% of total electricity generation, declining from an historic peak of 17.5% in 1996. New nuclear build is ongoing in 15 countries, with 48.5 gigawatt (GW) total capacity under construction. China dominates the new-build market, with 13 reactors under construction, with a capacity of 14 GW. Four newcomer countries are building reactors—Bangladesh, Belarus, Turkey and United Arab Emirates (UAE). However, 37 of the 53 new-build reactors are behind schedule, with 3 under construction for more than 30 years (Schneider et al., 2018).

In Europe, after a series of construction errors, significant cost-over-runs and associated delays; France and Finland are completing Electicité de France (EDF) Generation III European Pressurized Reactor (EPR) technologies at Flamanville 3 and Olkiluoto 3. Three further reactors are planned in Finland, two of which rely on investment and project management from Rosatom, the Russian state nuclear corporation, which is currently constructing 5 reactors on Russian soil. Bulgaria, Romania and Poland have announced plans for single reactor new-builds, and the Czech Republic has proposals to construct 2 reactors. The former Swedish nuclear phase-out policy has been reversed allowing for the replacement of existing reactors—but none proposed to date.

The UK, excluding Scotland, has in principle approved plans for a new generation of up to 8 reactors, subject to safety regulatory generic design assessment and finance approvals. However those plans have been subject to significant recalibration. Following the bankruptcy of Toshiba's US nuclear arm, Westinghouse, the Japanese conglomerate has withdrawn from new nuclear-build in the UK, citing expanding costs. Fellow Japanese corporation, Hitachi, has also recently scrapped its Wylfa plant in Anglesey, Wales, with a proposed second Hitachi plant in Oldbury, England, looking likely to be abandoned as well (Vaughan, 2019).

Further doubts have been cast over UK's new nuclear programme following the UK Parliamentary National Audit Offices' review of the economic case for the EDF EPR Hinkley Point C (HPC) project, which concluded that HPC was both risky and expensive for the UK taxpayer and energy consumer (NAO, 2017). The UK Parliamentary National Infrastructure Commission (NIC) also reported that Britain should not back more than one new nuclear plant after HPC before 2025,[1] noting that new renewable energy represented least-cost for consumers (NIC, 2018).[2]

Given that Germany uses circa 20% of all EU electricity, the Bundestag's post-Fukushima 2011 decision to close 7 of its 18 reactors, followed by the German Parliament vote to completely phase out nuclear power by 2022 and to invest in renewables, energy efficiency, grid network infrastructure, and plan for trans-boundary pumped-storage hydroelectricity, may prove significant for European energy policy as a whole. Germany has framed its nuclear-free energy policy in the context of national pride and scientific-technological achievement, twinned with economic expansion, and their *Energiewende*[3] is supported by all major German utilities and has cross-party political support.[4] In 2018, renewables overtook coal as Germany's main source of electricity, accounting for more than 40% of production. This takes place in the context of Europe's strongest economy aiming for 65% renewable electricity by 2030, whilst planning a progressive exit from coal (Reuters Environment, 2019). Here it's important to understand that decisions on nuclear cannot be separated from prior energy policy choices, and Germany has demonstrated a very strong, historic commitment to renewables, with innovative energy practice including the first implementation of a fixed price feed-in-tariff and huge uptake of solar photovoltaic (PV) technology.[5]

In Italy, voters passed a referendum to cancel plans for new reactors, with over 94% of the electorate voting in favour of the construction ban. Belgium has confirmed a nuclear phase-out, shuttering its 7 nuclear reactors by 2025.

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[1] Perhaps tellingly, Sir John Armitt, Chair of NIC, stated: "*Where, in the past, I've been a strong supporter of nuclear—I think that we are in a different world today. We don't have to be as dependent on a nuclear solution as maybe we thought we needed to be 10 years ago*" (Carbon Brief, 2018).

[2] NIC (2018) also noted that it was now possible to conceive of a low-cost electricity system that is principally powered by renewable energy sources.

[3] The *Energiewende* describes the non-nuclear German energy transition (Morris and Pehnt, 2018).

[4] One reason for this generalised policy support is that, per megawatt-hour generated, German renewables create more jobs than the fossil and nuclear sectors—Germany already has twice as many people employed in the renewables sector than in all other energy sectors combined.

[5] German energy policy has also devolved to the local level, with communities securing political agreements under which the Bundesländer (Federal States) are enabled to set goals and locations for renewable generation, thereby ensuring that local energy resources and financial subsidies (paid for by customers through feed-in tariffs, or taxpayers through cheap loans provided by the government development bank, KfW) benefit not only the energy companies but also the local people, with profits and employment kept in the region.

In Holland, the lone Dutch reactor at Borssele will remain open until 2033 only if it can prove compliance with safety standards. It is also worth noting that a 2011 pan-EU meeting in Vienna, including ministers and heads of delegations from Austria, Greece, Ireland, Latvia, Liechtenstein, Luxembourg, Malta and Portugal and observed by ministers from Cyprus, Denmark and Estonia, concluded that nuclear power was incompatible with the concept of sustainable development, stating that nuclear did not provide a viable option in combating climate change (Vienna Declaration, 2011). More recently, Spain announced the closure of its last nuclear reactors by 2030.

So, Europe seems oddly conflicted about new nuclear. Whilst some new-build is planned, the general post-Fukushima situation implies a diminishing role for new nuclear capacity in the coming decade. Combined with the ageing of nuclear power plants (NPPs)[6] and the finalisation of nuclear phase-out in Germany and other European countries, this trend may well lead to a relative decreasing share of electricity production sourced from EU nuclear energy, with the emphasis likely to shift towards maximising output of existing reactors through plant life extension (PLEX), up-grade and retrofit.

Likewise, global market trends for new nuclear are not entirely encouraging. Pre- Fukushima, the International Atomic Energy Association (IAEA, 2011) predicted that nuclear plants would add 360 GW of global generating capacity by 2035—the equivalent of over 200 new reactors. Extending a trend from earlier years, most projects were planned for Asia (including a significant dispersion of proposed reactors around the Pacific seismic region), and Eastern Europe (Leveque, 2011). After Fukushima, the IAEA halved this forecast, mainly due to security improvements, insurance premiums for nuclear accident-related damages, and resultant cost increases (IAEA, 2012). More recently, new-build plans have been cancelled in Turkey, Jordan, Malaysia, South Africa and the US, or postponed in Argentina, Indonesia, and Kazakhstan.[7] As the International Energy Agency's (IEA) annual World

[6] Western European Nuclear Regulators Association (WENRA) 'Stress Tests' comprised a targeted reassessment of the safety margins of NPPs in the light of Fukushima, including extreme natural events which challenge plant-safety functions, leading to severe accident (WENRA Task Force, 2011). However, since the European Nuclear Safety Regulators Group (ENSREG, 2011) decided that security issues were outside WENRAs remit, post-Fukushima stress tests of EUs 143 nuclear power reactors did not include accidents and incidents from an aeroplane strike or terrorist attack. The exclusion of these security issues seems unfortunate given that, for example, all UK civil nuclear infrastructures are uniquely implicated in all four high priority tier-one threats identified in the UK National Security Strategy (HM Government, 2010).

[7] Japan's Itochu pulled out of the Turkish Sinop project; two AP1000 units at V.C. Summers in the U.S., abandoned in 2017 after spending some US$5 billion on the project; and although South Africa signed an inter-governmental agreement with Russia to invest in 9,600 MW of nuclear reactors, supplied by Rosatom, this agreement was struck down by the South African High Court in 2018.

Energy Investment Report (IEA, 2018) suggests, nuclear investment is falling fast, dropping by 45% in 2017. Whilst global reported investment for the construction of the four commercial nuclear reactor project starts in 2017 is circa US$16, this compares unfavourably to US$280 billion in renewable energy investment, including over US$100 billion in wind power and US$160 billion in solar PV, with China investing US$126 billion (Schneider et al., 2018). Thus, global investment decisions on new commercial NPPs remain a factor of 8 below that of investments in renewables in China alone.

In this sense, the fate of new nuclear seems inextricably entwined with, and determined by, that of renewable energy technology roll-out. As the IEA reported, in 2017, 157 GW of renewables were added to the world's power grids, up from 143 GW added the previous year. The increase accounted for more than 61% of net additions to global power generating capacity. Of this, wind added 52 GW and solar PV 97 GW, compared to a 3.3 GW increase for nuclear power. This means that, in terms of 2017 global output growth, solar increased by 35%, wind by 17%, and nuclear by only 1% (IEA, 2018).[8] This trend continued in 2018, with global renewable generation capacity seeing the largest annual increase ever, and new solar outstripping additions in coal, natural gas and nuclear (REN21, 2018). The European Bank for Reconstruction and Development (EBRD) also stated that renewables were now cost-competitive with fossil fuels, even taking into account effective fossil fuel subsidies (Pyrkalo, 2018). Whilst ramping improvement in renewable technology is one explanation for this dynamic, the main driver seems to be the plummeting costs of renewable energy and the increasing costs of nuclear construction.[9]

3 Nuclear Costs

With nuclear construction, decommissioning, and waste management costs inexorably rising, is the pursuit of the nuclear project a viable and economically competitive option to other non-fossil fuel energy sources?

[8] The International Energy Agency (Renewable Energy World, 2018) concluded that a trillion watts of renewable power (1.3 terawatts) will be installed worldwide over the next five years—more than the entire current generation capacity of the EU—and by 2023, renewables will account for a third of total electricity generation worldwide.

[9] As Nobuaki Tanaka, former head of IEA and a long-standing nuclear advocate, noted: "*Nuclear power can't compete with solar power*", is "*ridiculously expensive*" and "*utterly uncompetitive*" (Asahi Shinbun, 2018).

Nuclear new builds are high-value and high-risk projects with a marked tendency for significant delay and delay claims, cost growth and investor risk (KPMG, 2011). Based on the experiences of 52 US investor-owned utilities that built NPPs between 1960–2011, the Texas Institute (2011) concluded that new nuclear plant projects provide significant economic risk, involving a 70% certainty that a power utility would see borrowing costs rise due to the downgrading of credit rating once construction began, with plant construction marred by significant cost overruns and electricity tariff increases.

Market analysis (Citi, 2009) has outlined five significant technical and financial risks, including planning, construction, power price, operation, and decommissioning. Citibank also noted that equity investment in nuclear pose core challenges, suggesting that it may be extraordinarily difficult to get non-recourse debt into new nuclear. And given the opportunity costs of nuclear combined with the proven tendency to significant cost increases and overruns, initial industry cost estimates for new-build have proven less than robust. For example, in the US, the construction of two AP 1000 Westinghouse nuclear reactors has been abandoned due to significant construction cost overruns. Another US project, Plant Vogtle, although still ongoing, has experienced a cost ramp from US$14bn to the latest estimate of US$25 billion (Schneider et al., 2018). Further, recent analysis of the history of NPP projects demonstrate that since 2010 delays have contributed 18% to costs (Portugal-Pereira et al., 2018) and, as discussed, 37 of the 53 units under construction are behind schedule, mostly by several years. China is no exception, with at least half of the 16 units under construction experiencing delays.

In Europe, the EDF EPR new-build in Olkiluoto, Finland have not gone well. Originally planned to go online early in 2009, the 1.6 GW Areva designed reactor was conceived as first of a type, with Siemens responsible for steam turbines and electricity generators. Originally priced at €3 billion, the project is now estimated at more than three times that level of costs and rising. The fixed price turn-key contract was subject to a prolonged dispute between the French manufacturer Areva and the Finnish nuclear corporation TVO, with the latter claiming costs for delays, finally settling on €450 million in compensation (WNN, 2018). Similarly, in France, EDF confirmed that the EPR Flamanville project was running late and increased its costs accordingly. Originally scheduled to start operating in 2012, it is hoped that the reactor may be operational by 2019. Originally priced at €3.3 billion, the reactor completion is currently estimated at €10.9 billion.[10]

[10] A significant quality-control scandal at the French nuclear construction corporation Areva's nuclear forge at Le Creusot further eroded confidence, resulting in share-value erosion and downgrading by credit-rating agencies. This was swiftly followed by a fiscal rescue and Areva was renamed Orano.

Nuclear plants, which are among the largest and most complex engineering projects in the world, also carry high technical and regulatory risks—with the World Nuclear Association (2017) showing very significant cost overruns for most projects, implying that utilities may only be able to pay for new plants if governments guarantee their income. Thus, costs and risks associated with nuclear construction may mean that plants can only be built with explicit and substantial state aid public subsidy, including loan guarantees, and long-term power purchase agreements (Professional Engineering, 2011). This is essentially what has happened in the UK.

4 Small Modular Reactors

In response to the construction and cost difficulties associated with large Generation III high burn-up reactors[11] (such as the French EDF EPR, the US Westinghouse AP 1000, and the Chinese CGN CNNC HPR-1), a step-change in emphasis associated with research and development of small modular reactors (SMRs) has been suggested (World Nuclear Association, 2015; BEIS, 2018). SMRs are nuclear reactors, generally 300 MWe equivalent or less, designed with modular technology.[12] Proponents suggest that SMRs can drive construction costs to more competitive levels through bulk modular assembly line reactor manufacture (Molyneux, 2017; IAEA, 2018b).

However, there are concerns with this theory. All recent nuclear design has been based around the concept of economies of scale.[13] This is because, for example, it is far more economic to build one 1.2 GW unit than a dozen 100 MW units. The economy of scale imperative applies equally to offshore wind power generation, where costs have significantly decreased due to larger unit construction. This key parameter implies that SMRs will be more

[11] Following the liberalisation of the EU energy market, it was realised that a decrease in nuclear costs could be achieved if reactor power could be optimised by using more uranium as reactor fuel and keeping the fuel rods in longer. Generation III reactor high burn-up spent fuel will be significantly more radioactive than conventional spent fuel, with consequent implications for nuclear waste management. Safety could depend on the effective and continuous removal of the significant thermal power of high burn-up spent fuel, potentially requiring additional pumps, back-up electricity supplies and back-up water supplies: all systems potentially vulnerable to mechanical failure or deliberate disruption. It is also likely that densely packed high burn-up spent fuel may require additional neutron absorbers, and greater radiation shielding during encapsulation and storage.

[12] In comparison, the large-scale EDF EPR reactor planned for Hinkley Point in the UK comprises 1,650 MW.

[13] Including the cost of trying to secure the containment under beyond design-based cascading fault conditions.

expensive than large reactors per KW/hr (kilowatt hour) (Sovacool and Ramana, 2014).

The creation of SMR assembly lines is also likely to prove costly, and the relative economics of SMR production may remain unproven until very many SMR units have been produced—which, paradoxically, cannot happen until a significant number of orders are placed, a circular dilemma. Similarly, the 'modular' SMR concept seems problematic, since in order to build modular capacity, a very full order book is needed—and in order to do so, *de facto* demonstration of SMR construction and operational capacity to time and cost must be proven. In this sense, SMR investment risk seems very great, perhaps even bigger than that of proposed large reactors (Cooper, 2014), since very significant up-front investment would be needed to establish an entire supply chain to sell scores of reactors needed to replace the lost economies of scale with the proposed economies of replication (Ramana, 2017). Correspondingly, this dynamic has resulted in demands for significant government assistance for SMR development. Thus, to date, the relatively poor economics of SMR deployment has been the key determinant, with the main US nuclear corporations, Westinghouse and Babcock & Wilcox, already pulling out of SMR development because of ramping cost problems.

Further, potential cost benefits of assembly line module construction relative to custom-build on-site construction may prove overstated. One reason is that production line mistakes may lead to generic defects that propagate throughout an entire fleet of reactors and are costly to fix, and experience with production-line construction of parts for the nuclear industry has proven troubling[14] (Ramana and Ahmad, 2016).

Further, SMRs produce exactly the same nuclear waste as conventional reactors per KWh, and any SMR roll-out among present non-nuclear states provides break-out proliferation potential (Glaser et al., 2013). Finally, since multiple, diverse and highly reliable active safety systems are needed to secure any form of nuclear plant, it is unfortunate to reflect that complex back-up design philosophy is incompatible with the small, compact, stripped-down design of the SMRs currently under consideration. One of the reasons is that SMR containment design implies a coupling of core and the containment, with potentially severe negative safety consequences (Ramana, 2018).

[14] For example, as discussed, regards the nuclear parts safety anomalies at former Areva's Le Creusot steel forge.

5 Nuclear and Climate Change

As discussed, a key plank of the new nuclear proponent argument rests with the claim that the technology is needed in order to manage the retreat from the fossil fuel economy. However, since not all low carbon technologies are equally efficient at reducing greenhouse gas emissions, this may not prove to be the case. Indeed, some are more carbon intensive and far less benign than others.

Since nuclear lifecycle emissions occur through plant construction, operation, uranium mining and milling, plant decommissioning and waste management, a meta-analysis screening 103 lifecycle studies of greenhouse gas-equivalent emissions for NPPs suggests that the reported range of emissions for nuclear energy over the lifetime of a plant has a mean value of 66 g CO_2 e/kWh, significantly higher than for most renewable energy technology carbon footprints (Sovacool, 2008), although see Wood (2018) for a discussion of the problems of renewable and low carbon energy definitions and carbon footprints. Earlier work by the Öko-Institute prefigures and supports the thrust of this analysis (Fritsche and Lim, 2006).

Perhaps more importantly, with ramping predictions for sea-level rise, and associated climatic disturbance, nuclear may prove an important risk, since climate change will impact coastal nuclear plants earlier and harder than industry, government or regulatory bodies have expected (Nerem et al., 2018; Vidal, 2018). According to the UK Institute of Mechanical Engineers (IME), coastal located nuclear reactors, together with radioactive waste stores including spent fuel, will be vulnerable to sea-level rise, flooding, storm surge and tsunami. Perhaps alarmingly, IME point out that these coastal nuclear sites may need considerable investment to protect them against rising sea levels, or even abandonment or relocation in the long term (IME, 2009). In this sense, adapting coastal nuclear power to climate change may entail significantly increased expense for construction, operation, waste storage and decommissioning (Kopytko and Perkins, 2011). And inland NPPs may fare no better. This is because, since all reactors must be cooled by significant amounts of water, they must shut down if that cooling water is either too warm or river flow is reduced. In France, since the majority of reactors are stationed by rivers and rely on river water for cooling, diminished river flow and increased water temperatures in summer time have already meant significant NPP shut-down, especially in the southern Rhone valley area (Reuters Business, 2018).

6 Nuclear Liability

Choices need to be made as to which low carbon technologies are best equipped to replace fossil fuels. In doing so, it is critically important to identify and differentiate between available options—since some carry much greater risks than others.

The risk to people, the environment, and to the future of nuclear energy as a consequence of a major incident is significant. A recent cost estimate for the accident at Chernobyl, based on an extensive review of the literature, places the liability at US$700 billion (Samet and Seo, 2016). Current cost estimates for the Fukushima accident is YEN218 billion, a 58% rise from the previous official estimate of YEN126.4 billion (Japan Times, 2018). Thus, events at Chernobyl and Fukushima tend to support the conclusion that reactor accidents may prove the single largest financial risk facing the nuclear industry, far outweighing the combined effect of market, credit, and operational risks.

In Europe, the Paris Convention on Nuclear Third Party Liability and Brussels Convention (2011) ensures that nuclear operators are liable for the first EUR 700 million for any one accident, with the national government having the option of adding a maximum of a further €500 million towards the company's liabilities. Collectively, other EU signatory states may contribute a further €300 million, potentially bringing the total available to €1,500 million for any one accident. Yet actuarial analysis suggests that even this level of cover may fail to account for liability in case of major accident. Versicherungsforen Leipzig GmbH (2011), a company that specialises in actuarial calculations, concluded that accident costs were not adequately internalised, suggesting that full insurance against nuclear disasters would increase the price of nuclear electricity to a sum that considerably weakens the economic case for nuclear power compared to other low-carbon sources. Both the required liability (€6.09 trillion), based on an estimate of the average maximum damage and corresponding variance, and the resulting insurance premium, are significantly higher than the financial resources currently legally required of 22 operators. Versicherungsforen Leipzig's study estimated that future damage and liability insurance costs would exceed the financial resources that NPP licensees are currently required to maintain by several orders of magnitude. In this context, nuclear disasters seem uninsurable, due to a combination of methodological difficulties in estimating the probability of occurrence of damage, insufficient size of the risk pool, and the extent of potential maximum damage (ibid.).

Further, to the extent that liability rules provide incentives for prevention, the financial limit on the liability of an operator may lead to under-deterrence—since, as a result of the financial cap on liability, the potential complementary function of liability rules in providing additional deterrence may be lost. The financial limit, and the resulting nuclear subsidy, may also distort competition by unduly favouring nuclear energy compared to other energy sources (Faure and Fiore, 2009).

The issue of nuclear waste and decommissioning liability has been subject to intense and prolonged debate. In Europe, differing EU nuclear states have set aside differing sums for decommissioning. For example, whereas Germany has set aside €24 billion to decommission 17 nuclear reactors, and the UK NDA estimates that clean-up of UK's 17 nuclear sites will cost between €109–250 billion over the next 120 years—France has set aside only €23 billion for the eventual decommissioning of its 58 reactors. To put this in context, according to the European Commission, France estimate it will cost €300 million per GW of generating capacity to decommission a nuclear reactor—far below Germany's assumption at €1.4 billion per GW and the UK of €2.7 billion per GW (Dorfman, 2017). Correspondingly, the French National Assembly's Commission for Sustainable Development and Regional Development reported that the decommissioning of French reactors will take longer, will be more challenging, and cost much more than EDF had anticipated (Assemblée National, 2017a, b).

7 Nuclear Probabilistic Risk Assessment

Key to the analysis of nuclear safety is the analytical concept of probabilistic risk assessment (PRA). Risk in PRA is defined as a feasible detrimental outcome of an activity or action characterised by two quantities: the magnitude (severity) of the possible adverse consequences, and the likelihood (probability) of occurrence of each consequence. Whilst PRA calculations are not taken as absolute (but rather as significant indicators of plant weaknesses), they do underpin the key regulatory concepts of 'acceptable risks' and 'tolerable consequences' under fault conditions (Dorfman, 2013). In this context, the risk of an accident must be acceptable, and the radiological consequences tolerable, with more frequently occurring incidents countered by greater resilience through enhanced safety systems grounded in robust engineered structures. However, PRA has proven structurally limited in its ability to conceive and capture the outcomes and consequences of a nuclear accident resulting from a cascading series of events, as described in the Fukushima disaster and all previous major nuclear accidents. This implies that relatively simplified chain-of-event fault-tree PRA models may not be sufficient to account for the indirect, non-linear, and feedback relationships common for accidents in complex systems. Here, modelled common-cause, common-mode, and dependent failures have proved problematic; partly due to data limitation (since major failures occur infrequently), and because failure mechanisms are often plant specific (Dorfman et al., 2013).

Whilst most PRA models assume failure likelihood can be captured through identical, independent log-normal failure distributions—since strong independence assumptions employed in PRAs assume that reactor safety systems are duplicated and reliable, core damage frequency estimates are typically very low. Because of this, there may be good reason to question the conceptual and theoretical completeness, and empirical and practical reliability of PRA models. This is partly because PRA is prone to under-counting accident scenarios—since risk is estimated for enumerated reactor states, failure to account for unknown and serially cascading beyond design-base accident scenarios leaves an un-measurable model error in the core damage frequency estimate (Maloney, 2011).

For example, before the Fukushima accident, the Japanese Nuclear Regulatory Commission Guidance (NSC, 2006), updated in early 2011, concluded that robust sealed containment structures would prevent damage from a tsunami, and no radiological hazard would be likely. Whereas after the accident, the Chairman and President of the European Nuclear Society High Scientific Council stressed that the magnitude of the tsunami that struck Japan was beyond the design value to which the reactors were supposed to withstand (Bonin and Slugen, 2011). These pre and post-facto statements suggest that, although reactor design can prove relatively robust safety cannot be guaranteed for cascading beyond design-base accidents. In the case of Fukushima, because the cascade from earthquake, through tsunami, to reactor and spent fuel fault condition was discounted, no account was taken for the need to respond to the failure of three nuclear reactors and spent fuel ponds.

Pre-Fukushima probability estimates of a major nuclear accident were around 1:100,000 for the 440 reactors in operation over the subsequent 25 years. Post-Fukushima, estimated probability of major nuclear accidents has increased significantly. Yet, estimation of core melt and containment failure may still prove problematic. Chernobyl and Fukushima together comprise catastrophic meltdown in four nuclear reactors over the past few decades, implying that that the probability of a major accident in the current worldwide fleet over the next 20–25 years is around 1:5,000. Thus, whereas earlier estimates assumed a probability of one major nuclear accident over a 100-year period, reoccurrence of these events can be expected once every 20 years (Goldemberg, 2011). This reassessment of nuclear risk is particularly apparent in Germany, where Chancellor Angela Merkel concluded that Fukushima had forever changed the way Germany defined nuclear risk (Schwägerl, 2011); an analysis echoed by Norbert Röntgen, Germany's Environment Minister, who noted that Fukushima had swapped a mathematical definition of nuclear energy's residual risk with a terrible real-life experience, adding that he can no longer put forward the argument of a tiny risk of 10 to the minus 7 (ibid.).

Importantly, the German Govt. Advisory Council on the Environment (SRU) concurred with this critique, suggesting that:

> The *widespread view that the extent of the damage due even to major incidents can be adequately determined and limited in order to be weighed up… is becoming considerably less persuasive… The fact that the accident was triggered by a process which the nuclear reactor was not designed to withstand… casts a light on the limitations of technological risk assessment… based on assumptions, and that reality can prove these assumptions wrong*. (SRU, 2011: 11)

Correspondingly, since levels of reliability required for a complex interactive and tightly coupled NPP are very great (Perrow, 1984), with the range of operating reactors having differing sets of designs and configurations, and because of the complexity of physical conditions during reactor operation; the understanding of reactor design and operation and, hence, likelihood of accident, is always partial. Since system components and external events can interact in unanticipated ways, it is impossible to predict all potential failure modes, it follows that numerical estimates of probabilities of significant accidents remain deeply uncertain. As the Fukushima Investigation Committee concluded (2011: 22): "The *accidents present us* [with] *crucial lessons on how we should be prepared for… incidents beyond assumptions*".

It is worth recalling that NPPs are vulnerable to unforeseen external events or through human or engineering-based fault conditions, including accidental or deliberate harm. Accidents are by nature, accidental, and the cost of ignoring this common-sense axiom can prove radiologically catastrophic (Stirling, 2011). Part of the problem is that nuclear facilities are so complicated that, given the unpredictability of unforeseen natural and other events (including terrorist attacks), it may prove almost impossible to assess such matters with confidence.

8 Radiation Risk

The concept of risk is key to better understanding the relative role of nuclear in the context of post-fossil fuel energy policy decision-making. Because of the consequence of risks associated with nuclear, that energy pathway may prove a far less rational choice in an increasingly uncertain safety and security landscape—and fundamental radiation risk science is still indeterminate.

Radiation risk dramas are performed on darkly lit stages surrounded by profound epistemological uncertainty, and some argue that the contextual sub-plots of the actors are deliberately obscured by the exigencies of policy goals associated with military deterrence (Stirling and Johnstone, 2018). Direct attention to the question of risk and associated health impacts from chronic radiation releases to the environment from civil and military reactors, transports, waste and decommissioning, has emerged almost as an afterthought to the operationalisation of the nuclear project.

Since concerns about potential human health consequences from significant accident and incidents (and even normal releases from operational, waste and decommissioning processes) drive all other upstream costs (such as reactor and nuclear island containment, defence from attack); nuclear safety regimes, based on radiation epidemiology and radiation biology, are absolutely central to the nuclear issue. So often occluded in the energy management literature, it remains vitally important to engage with aspects of this complex and contested and, as yet, unresolved debate—which has both a history and a trajectory.

Scientific radiation risk assessment is dependent on differing epidemiological and biological experimental data. Studies concerning the interaction of ionising radiation and the living environment (to determine differing pathways to, uptake of, and metabolism by differing soils, plants, and organisms) take many forms. The most direct experiment is that between humans and radiation (radiation exposure to humans). This involves the identification of the concentration, quantity, and quality of radioactive pollutant, it's pathway through the environment and, finally, its uptake and metabolism within the human receptor.

These data sets are subject to fundamental scientific radio-biological (mechanistic) and radio-epidemiological (direct effect) research involving differing quantities and qualities of ionising radiation, as delivered to differing receiving ecosystem stages at population, community, organism, molecular and cellular levels. The cumulative outcome of this research provides data concerning both somatic[15] and genetic effects,[16] which are then translated into models of environmental management via filtration through, and validation by, international and national scientific advisory bodies. In turn, these scientific advisory bodies produce institutional knowledge concerning radiation risk, which are then embodied in incrementally evolving sets of regulatory safety regimes. All the above are intimately interwoven and interrelate. Fundamental science and, hence, nuclear risk regulation attempt to successfully account for these interactions via an extraordinary weight of directed research.

8.1 Radiation Epidemiology

Epidemiological method, the analysis of incidence and distribution of disease, is fundamental to radiation risk determination and standard setting (Lindell, 1996). However, whilst epidemiology can provide direct information about the relationship between environmental pollution and community well-being or ill-health, this information is methodologically inferential rather than causal. As with all quantitative data, results are dependent on the completeness of preceding data. This can prove problematic—since complete information about individual or population radiation dose and exposure may be variable or uncertain. This issue is especially important for historic exposure to humans. For instance, estimation of radiation exposure to groups such as Hiroshima and Nagasaki A-bomb survivors (the single most important information set concerning the effects of radiation on human organisms) has been subject to vigorous controversy and reinterpretation (Stewart and Kneale, 2000).

There also remains significant uncertainties associated with the choice of differing models used to interpolate radiation risk between populations with different background disease rates; for the projection of risk over time; for the extrapolation of risks following primarily a single external high dose and high dose-rate radiation exposure (following Japan A-Bomb detonations) in contrast to cumulative low dose and low dose-rate exposure (following NPP releases under normal operating conditions). Despite this, the epidemiological analysis of incidence and distribution of disease remains fundamental to radiation-risk determination and nuclear protection standard setting. Epidemiological investigations ranging from A-bomb survivor studies to more numerically and temporally limited studies have provided an enormous

[15] Somatic effects occur in an individual who has been exposed to ionising radiation.

[16] Genetic effects occur in the descendants of a parent whose DNA molecules are modified due to exposure to ionising radiation.

weight of evidence about the effects of ionising radiation on humans, and because the association between radiation and the aetiology of cancer and leukaemia is well-rehearsed in the published peer-reviewed literature, this aspect of the debate has devolved to an intense, long-lived, and at times vitriolic discussion of the risks of disease incidence, in particular childhood cancer and leukaemia, in the vicinity of nuclear installations.

Whilst a range of studies suggests no causal or associative link between routine discharges from operating nuclear plants and increased incidence of ill-health amongst nearby populations, sub-populations, communities, and individuals (Jablon et al., 1991; Yoshimoto et al., 2004; Evrard et al., 2006; COMARE, 2011), this important debate is ongoing, and there exists compelling evidence to the contrary. One of the most significant data sets comprises a national case-control study, funded and published by the Federal Office for Radiation Protection on behalf of the German Federal Ministry for the Environment and conducted by the German Childhood Cancer Registry on childhood cancer near nuclear installations. This study investigated childhood leukaemia and cancer incidence near all German (i.e. in both former West and East Germany) between 1980 to 2003, providing evidence of a significant increase in childhood leukaemia and cancer risk within 20 km of a NPP (Kaatsch et al., 2007, 2008a, b; Spix et al., 2008). The German Federal Office for Radiation Protection (BfS) formally confirmed these findings, stating that an increased risk of 60% was observed for all types of childhood cancer, and that for childhood leukaemia, the risk doubled (BfS, 2008). In response, the UK scientific advisory Committee on Medical Aspects of Radiation in the Environment (COMARE) 14th Report (2011) critiqued the German study and stated that there was no evidence of either an association or causal link between increased risk of childhood cancer or leukaemia and living near to any UK NPP (COMARE, 2011). COMARE suggested that the acknowledged childhood leukeamia cluster near to the UK Sellafield nuclear facility was probably caused by an unidentified viral infection rather than radiation exposure, citing the potential role of population mixing theory (PMT) in the aetiology of childhood cancer and leukaemia near NPP (Kinlen, 2011).[17] Thus, even at the highest levels of investigation, and between two scientifically

[17] PMT proponents claim that any excess childhood leukaemia incidence near NPP are caused by an unidentified virus, brought in by nuclear construction workers, which is then passed on to local infants and children. In other words, the suggestion is that enhanced contact between incoming and resident sub-populations promotes the exchange via 'herd-mingling' of an unidentified virus that causes leukaemia. This theory has also been roundly critiqued.

advanced European states, there exists no consensual agreement on, or settlement over, this key aspect of the radiation risk debate.[18]

8.2 Radiation Biology

The second main strand of radiation protection research is radiation biology, which interrogates the underlying mechanisms by which radiation interacts with living organisms. Radiation biology is dominated by deterministic scientific investigation at the complex cellular and cellular response levels.

The theoretical underpinning of the biological effects of ionizing radiation is based on sophisticated variants of target theory, such as track structure theory. Target theory stipulates that the biological targets damaged in the cell are relevant to the endpoint: for example, damage to a tumour suppressor gene might lead to cancer. Whilst target theory holds for single locus hereditary disease, there remain problems in applying it to somatic endpoints such as cancer. As early as 1992, evidence inconsistent with target theory emerged in the form of 'genomic instability' (Kadhim et al., 1992) and the 'bystander effect' (Nagasawa and Little, 1992). Such effects are collectively known as 'non-targeted effects' because in this context the target is large enough to encompass the whole nucleus of the cell and, via the bystander effect, radiation does not directly affect the damaged cell. Perhaps the most worrying aspect from the public health perspective is the potential for trans-generationally inherited genomic instability characterised by the *de novo* acquisition of various kinds of damage, mostly to DNA, up to several cell generations after the exposure. In other words, damage associated with genomic instability may not clinically present in those first exposed, but in their children or grandchildren. More perplexingly, via the bystander effect, this damage has been observed to occur in cells that experience no direct radiation but are neighbours of cells that have been exposed (ibid.).

These phenomena continue to pose sets of significant questions for the understanding of the underlying mechanisms involved and may imply some re-appraisal of elements of the target theory approach and, hence, current radiation protection regulatory philosophy. Whilst two European Commission projects specifically directed at obtaining a better understanding of genomic

[18] Which has recently been further complicated through suggestions by pediatricians that infants and children are more likely to experience higher external and internal radiation exposure levels than adults (and, hence, be at greater risk) because of their smaller body and organ size and other physiologic characteristics, as well as their tendency to pick up contaminated items and consume contaminated milk or foodstuffs (Linet et al., 2018).

instability, have reported[19]—so far, no replacement for the underpinning framework based on target theory has emerged. This may be because, as usual with radiation biology, the picture is complex, especially in distinguishing between the interpretation of results from *in vitro* and *in vivo* studies.[20] Later work indicates that additional mechanisms may also be important for the understanding of the impact of genomic instability and bystander effects on radiation protection regulation. Mukherjee et al. (2012) suggest that radiation-induced chromosomal instability may also result from inflammatory processes having the potential to contribute secondary damage expressed as non-targeted and delayed radiation effects. Lorimore et al. (2011) conclude that complex multi-cellular interactions resulting from bystander effects may influence carcinogenic susceptibility, with inflammatory processes responsible for mediating and sustaining the durable effects of ionizing radiation. Given that the genotype[21] of each individual is a key determinant of carcinogenic susceptibility, then genotype-directed tissue responses may be important determinants of understanding the specific consequence of radiation exposure in different individuals (Lorimore et al., 2011). One potentially significant implication of this finding is that differing people may have differing responses and susceptibilities to radiation insult. In other words, it seems likely that there are groups of people who are at greater risk from radiation than the general population, and these sub-populations may not be adequately protected by current radiation-protection standards.[22]

So there seems to be an irrational paradox at the core of the radiation risk issue. Whilst there exists significant fundamental scientific uncertainty about important elements of its founding evidence—perplexingly, all decisions concerning the actual regulation of nuclear pollution are based on the language of certainty. In this sense, the flow of information between complex fundamental science and its progeny, should be rather like a *Russian Doll*, with each data set transitively sitting in, and recursively dependant on, each other. Yet, in practice, this flow of evidence seems more like a *Chinese Whisper*, with

[19] RISC-RAD (http://riscrad.org/) and NOTE (http://www.note-ip.org).

[20] *in vivo* experiments are those carried out inside a living organism (e.g. an animal), and *in vitro* involves experiments carried on outside a living organism (e.g. in a test tube).

[21] Genotype is the part of the genetic makeup of a cell (and therefore of any person) which determines one of its characteristics or traits.

[22] Although elements of genetic aspects of individual sensitivity are rehearsed as a factor of uncertainty in current radiation protection (e.g. whether there might be a significant fraction of the population who might be at greater risk), it is important to stress that there is also uncertainty about the level of deleterious effects that radiation has on these susceptible sub-groups, and also about the genetic distribution of phenotypes of these susceptible sub-groups within the general population.

information being altered in translation, and the final message failing to relate sufficiently to its origin, purified from its problematic modifier—risk.

9 Conclusion

Perhaps the key analytical conclusion to be drawn from this chapter concerns the multi-factorial nature of the nuclear issue, which incorporates sets of cross-cutting and interwoven phenomena, each transitively dependent on the other—and how, in turn, this complex hybrid may impact on future energy policy choices. For example, the fate of new nuclear seems inextricably entwined with, and determined by, that of renewable energy technology roll-out. Thus, whilst global market trends for new nuclear are declining, and renewables rising—the, perhaps obvious, explanation of this dynamic can be found in the ramping costs of the former and the plummeting costs of the latter (Elliott, 2017; Toke, 2018). In this sense, not all lower carbon options are equal, and there are choices to be made. Whilst nuclear proponents argue that future energy needs could be met via a combination of nuclear and renewables—given the existential costs of nuclear, the real choice may well prove to be nuclear or renewable. This is because new nuclear plants carry very high technical, regulatory and investment risk, showing very significant cost overruns, and despite arguments to the contrary, prospects for small modular reactor development seem no better.

There seems no resounding new revelations over the vulnerability of nuclear power to unforeseen natural disasters like earthquakes and tsunamis, or through human or engineering-based fault conditions, including accidental or deliberate harm. Accidents are by nature, accidental, and the cost of ignoring this common-sense axiom can prove radiologically catastrophic (Stirling, 2011). Whatever one's view of the risks and benefits of nuclear energy, it is clear that the possibility of catastrophic accidents must be factored into post-fossil fuel energy policy and regulatory decision-making processes.

Given the degree of uncertainty and complexity attached to even the most tightly framed and rigorous nuclear risk assessment, attempts to weight the magnitude of accident by the expected probability of occurrence has proven problematic—since these essentially theoretical calculations can only be based on sets of pre-conditioning modelled assumptions. This is not an arcane philosophical point, but rather a very practical issue with significant implications for the proper management of nuclear risk. With its failure to plan for unexpected beyond design-base cascading accidents, regulatory emphasis on risk-based probabilistic assessment has proven limited, and even enhanced current major accident liability regimes will prove inadequate to meet the cost of any further nuclear disasters.

Whilst some argue that nuclear may help ameliorate the effects of global heating, because climate change will impact coastal nuclear plants earlier and harder than the nuclear industry, government, or regulatory bodies currently estimate, nuclear may prove more risky than helpful. In this context, it may prove critically important to sequester significant funds in order to attempt to defend and adapt coastal nuclear sites to hazards associated with swiftly rising sea levels, storm surges, flooding and the likelihood of eventual nuclear islanding.

Although foresight and precaution are key to the management of nuclear risks, a paradox lies at the heart of the issue: Whereas significant aspects of fundamental cost, liability, risk assessment, reactor design, and radiation protection science and technology are characterised by very real uncertainty, indeterminacy and contingency—the regulation, construction, finance and operation of nuclear facilities are based on the language of certainty. In other words, the nearer one gets to the fundamental science of nuclear systems, the greater the uncertainty and complexity—yet the nearer one gets to regulation and operation, the greater the certainty and simplicity. The result of this process of translation is the deployment of over-simplified 'black-boxed' knowledge. Questions for further research include: how, where, and why does this happen?

In the journey to manage the decline of fossil fuels, nuclear power (a quintessentially late twentieth century technology) will struggle to compete with the technological, economic and security advances and advantages of the coming renewable evolution. In bidding a long goodbye to coal, we may also be bidding adieu to nuclear—and given the associated ramping cost and risk issues that cling to nuclear power, perhaps not before time.

References

Assemblée National. 2017a. *En application de l'article 145 du Règlement relative à la* faisabilité technique et financière *du* démantèlement des installations nucléaires de base, Enregistré à la Présidence de l'Assemblée nationale le 1er février 2017.

Assemblée National. 2017b. Rapport d'information: Déposé en application de l'article 145 du Règlement Par La Mission D'Information relative à la faisabilité technique et financière du démantèlement des installations nucléaires de base au nom de la commission du dévelopment durable et de l'aménagement du teritoire et présenté par M. Julien Aubert, Président and Mme Barbara Romagnan, Rapporteure Députés, No. 4428. http://www.assemblee-nationale.fr/14/rap-info/i4428.asp.

BEIS (UK Department of Business, Energy and Industrial Strategy). 2018. Advanced Nuclear Technologies, Policy Paper, BEIS, Updated December 17, 2018. https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies.

BfS (German Federal Office for Radiation Protection). 2008. Unanimous Statement by the Expert Group Commissioned by the Bundesamt fur Strahlenschutz on the KiKK Study, Berlin, Germany, 2007.

Bonin, B. and Slugen, V. 2011. Statement on the Japanese Nuclear Accident, European Nuclear Society (ENS) High Scientific Council, European Nuclear Society.

Carbon Brief. 2018. The Carbon Brief Interview: Sir John Armitt, November 13, 2018. https://www.carbonbrief.org/the-carbon-brief-interview-john-armitt?utm_content=buffer559c6&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer#nuclear.

Citi. 2009. New Nuclear—The Economics Say No, UK Green Lights New Nuclear—Or Does It? November 9, 2009. http://npolicy.org/article_file/New_Nuclear-The_Economics_Say_No.pdf.

COMARE (Committee on Medical Aspects of Radiation in the Environment). 2011. Further Consideration of the Incidence of Childhood Leukaemia Around Nuclear Power Plants in Great Britain, Fourteenth Report, Chairman: Professor A Elliott, HMG.

Cooper, M. 2014. Small Modular Reactors and the Future of Nuclear Power in the United States. *Energy Research & Social Science* 3(September): 161–177.

Dorfman, P. 2004. The Performance of Knowledge in the Low Level Radiation Risk Debate. Unpublished PhD, UWE, Bristol.

Dorfman, P. 2013. Witness Statement, UK High Court, wCO/5020/2013. In The Administrative Court, Between: An Taisce (Claimant) and The Secretary of State for Energy and Climate Change (Defendant), and NNB Generation Company Ltd (Interested Party), 2013, London.

Dorfman, P. 2017. How Much Will it Really Cost to Decommission the Aging French Nuclear Fleet? *Energy Post*, March 15, 2017. https://energypost.eu/how-much-will-it-really-cost-to-decommission-the-aging-french-nuclear-fleet/.

Dorfman, P., Fucic A. and Thomas, S. 2013. Late Lessons from Chernobyl, Early Warnings from Fukushima. In: *Late Lessons from Early Warnings: Science, Precaution, Innovation*, EEA Report, No. 1/2013, ISSN 1725-9177, European Environment agency (EEA).

Ekins, P., Drummond, P. and Goerlach, B. 2017. Policy Instruments for Low-carbon Development Based on Work from the EUFP7 Project, CECILIA2050: Combining Policy Instruments to Achieve Europe's 2050 Climate Targets, *Climate Policy* 17 (Supp. 1): S1–S7.

Elliott, D. 2017. *Nuclear Power, Past Present and Future*. IOP Science, Morgan and Claypool.

ENSREG (European Nuclear Safety Regulators Group). 2011. EU Stress Tests Specifications http://www.ensreg.eu/node/289/.

Evrard, A-S., Hémon, D., Morin, A., Laurier, D., Tirmarche, M., Backe, J-C., Chartier, M. and Clavel, J. 2006. Childhood Leukaemia Incidence around French Nuclear Installations Using Geographic Zoning Based on Gaseous Discharge Dose Estimates. *British Journal of Cancer* 94(9): 1342–1347.

Faure, M.G. and Fiore, K. 2009. An Economic Analysis of the Nuclear Liability Subsidy. *Pace Environmental Law (PELR) Review 26*(2), 2009. Available at SSRN: https://ssrn.com/abstract=1503327.

Fritsche, U.W. and Lim S. 2006. Comparison of Greenhouse-Gas Emissions and Abatement Cost of Nuclear and Alternative Energy Options from a Life- Cycle Perspective, Energy & Climate Division Öko-Institut, Darmstadt Office.

Glaser, A., Hopkins, L.B. and Ramana, M.V. 2013. Resource Requirements and Proliferation Risks Associated with Small Modular Reactors. *Nuclear Technology* 184(1): 121–129.

Goldemberg, J. 2011. Oil Price. http://oilprice.com/Alternative-Energy/Nuclear-Power/Have-Rising-Costs-and-Increased-Risks-Made-Nuclear-Energy-a-Poor-Choice.html.

HMG (Her Majesty's Government, UK). 2010. A Strong Britain in an Age of Uncertainty: The National Security Strategy, Presented to Parliament by the Prime Minister, October 2010, Cm. 7953, Stationery Office, London.

IAEA (International Atomic Energy Association). 1999. Basic Safety Principles for Nuclear Power Plants 75-INSAG-3 Rev. 1, A Report by the International Nuclear Safety Advisory Group, INSAG Series No. 12.

IAEA (International Atomic Energy Association). 2011. *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*, 2011 ed., REF Data Series No. 1, IAEA.

IAEA (International Atomic Energy Association). 2012. *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*, 2012 ed., REF Data Series No. 2, IAEA.

IAEA (International Atomic Energy Association). 2018a. *Preparation, Conduct and Evaluation of Exercises to Test Security Contingency Plans at Nuclear Facilities*, IAEA-TDL-008 (ISBN: 978-92-0-107418-8).

IAEA (International Atomic Energy Association). 2018b. *Deployment Indicators for Small Modular Reactors, Methodology, Analysis of Key Factors and Case Studies*, TECDOC Series No. 1854, IAEA-TECDOC-1854, 978-92-0-105718-1, Sept 2018.

IME (Institution of Mechanical Engineers). 2009. *Climate Change: Adapting to the Inevitable*. Westminster and London: Institution of Mechanical Engineers.

International Energy Agency (IEA). 2018. World Energy Investment 2018. https://webstore.iea.org/world-energy-investment-2018.

Investigation Committee. 2011. *Investigation Committee on the Accidents at Fukushima Nuclear Power Stations of Tokyo Electric Power Company*, Executive Summary of the Interim Report, Provisional, 26 December 2011.

IPCC (International Panel on Climate Change). 2018. *Global Warming of 1.5°C: An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. https://www.ipcc.ch/pdf/special-reports/sr15/sr15_spm_final.pdf.

Jablon, S. Hrubec, Z. and Boice, J.D. 1991. Cancer in Populations Living Near Nuclear Facilities, Report of a Survey by Researchers at the US National Cancer Institute. *Journal of the American Medical Association* 265: 1403–1408.

Japan Times. 2018. Estimated Cost of Fukushima Disaster Might Balloon to ¥218 Billion, March 24, 2018. https://www.japantimes.co.jp/news/2018/03/24/national/estimated-taxpayer-cost-fukushima-nuclear-disaster-balloons-%C2%A5218-2-billion/.

Kaatsch, P., Spix, C., Schmiedel, S., Schulze-Rath, R., Mergenthaler A. and Blettner M. 2007. Epidemiologische Studie zu Kinderkrebs in der Umgebung von Kernkraftwerken (KiKK-Studie). Zusammenfassung.

Kaatsch, P., Spix, C., Schulze-Rath, R., Schmiedel, S. and Blettner, M. 2008a. Leukaemia in Young Children Living in the Vicinity of German Nuclear Power Plants. *International Journal of Cancer* 122: 721–726.

Kaatsch, P., Spix, C., Jung, I. and Blettner, M. 2008b. Childhood Leukemia in the Vicinity of Nuclear Power Plants in Germany. *Deutsches Ärzteblatt International* 105: 725–732.

Kadhim, M.A., Macdonald, D.A., Goodhead, D.T., Lorimore, S.A., Marsden, S.J. and Wright, E.G. 1992. Transmission of Chromosomal Instability After Plutonium Alpha-Particle Irradiation. *Nature* 355(6362): 738–740.

Kinlen, L. 2011. Childhood Leukaemia, Nuclear Sites, and Population Mixing. *British Journal of Cancer* 104(1): 12–18.

Kopytko, N. and Perkins, J. 2011. Climate Change, Nuclear Power, and the Adaptation-Mitigation Dilemma. *Energy Policy* 39(1): 318–333.

KPMG (Klynveld Peat Marwick Goerdeler). 2011. Construction Risk in New Nuclear Power Projects—Eyes Wide Open. KPMG International.

Leveque, F. 2011. Nuclear Outlook in the EU by 2020 and Beyond. *Energy Policy Blog*, June 18, 2011.

Lindell, B. 1996. The History of Radiation Protection. *Radiation Protection Dosimetry* 68(1–2): 83–95.

Linet M.A., Kazzi Z. and Paulson J.A. 2018. Pediatric Considerations Before, During, and After Radiological or Nuclear Emergencies. *Pedriatics* 142(6), e20183001.

Lorimore, S.A., Mukherjee, D., Robinson, J.I., Chrystal, J.A. and Wright, E.G. 2011. Long-lived Inflammatory Signaling in Irradiated Bone Marrow is Genome Dependent. *Cancer Research* 71: 6485–6491.

Maloney, S. 2011. Assessing Nuclear Risk in the Aftermath of Fukushima. *Energy Risk*, July 11, 2011.

Molyneux, J. 2017. UK Industrial Readiness for SMR, World Nuclear New Build Congress, 12 September 2017. Presentation, John Molyneux, Director of Engineering and Technology, Rolls-Royce Civil Nuclear.

Morris, C. and Pehnt, M. 2018. The German Energiewende eBook, Energy Transition. Heinrich Böll Foundation. https://book.energytransition.org/.

Mukherjee, D., Coates, P.J., Lorimore, S.A. and Wright, E.G. 2012. The In Vivo Expression of Radiation- Induced Chromosomal Instability Has an Inflammatory Mechanism. *Radiation Research* 177: 18–24.

Nagasawa, H. and Little, J.B. 1992. Induction of Sister Chromatid Exchanges by Extremely Low Doses of Alpha-particles. *Cancer Research* 52: 6394–6396.

NAO (National Audit Office). 2017. Hinkley Point C, Report by the Comptroller and Auditor General, Department for Business, Energy & Industrial Strategy. https://www.nao.org.uk/wp-content/uploads/2017/06/Hinkley-Point-C.pdf.

Nerem, R.S., Beckley, B.D., Fasullo, J.T., Hamlington, B.D., Masters, D. and Mitchum, G.T. 2018. Climate-Change—Driven Accelerated Sea-Level Rise Detected in the Altimeter Era, *PNAS* 115 (9): 2022–2025.

NIC (National Infrastructure Commission). 2018. National Infrastructure Assessment, July 2018. https://www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf.

NSC (Nuclear Safety Commission). 2006. Safety Evaluation, NSC Regulatory Guide, Japanese Nuclear Safety Commission.

Paris Convention. 2011. Protocols to Amend the Brussels Supplementary Convention on Nuclear Third-Party Liability, No. 26, February, 2011.

Perrow, C. 1984. *Normal Accidents: Living with High Risk Technologies*, Revised ed., 1999. Princeton, NJ: Princeton University Press.

Portugal-Pereira, J., Ferreira, P., Cunha, J., Szklo, A., Schaeffer, R. and Araujo, P. 2018. Better Late Than Never, but Never Late is Better: Risk Assessment of Nuclear Power Construction Projects. *Energy Policy* 120(September): 158–166.

Professional Engineering. 2011. Funding for Nuclear Expansion: Costs and Risks Associated with Nuclear Construction Raise Further Questions, 3 October 2011, Professional Engineering.

Pyrkalo, S. 2018. EBRD Says Renewables are Now Cheapest Energy Source. *European Bank for Reconstruction and Development (EBRD)*, October 7, 2018. https://www.ebrd.com/news/2018/ebrd-says-renewables-are-now-cheapest-energy-source-.html.

Ramana, M.V. 2017. Challenges of Small Modular Reactors, Liu Institute for Global Issues, School of Public Policy and Global Affairs, University of British Columbia, Energy Studies Institute, Singapore, 27 October 2017.

Ramana, M.V. 2018. Small Modular Reactors for Nuclear Power: Hope or Mirage? *Energy Post*, February 21, 2018. https://energypost.eu/small-modular-reactors-for-nuclear-power-hope-or-mirage/.

Ramana, M.V. and Ahmad, A. 2016. Wishful Thinking and Real Problems: Small Modular Reactors, Planning Constraints, and Nuclear Power in Jordan. *Energy Policy 93*: 236–245.

REN21. 2018. *Renewables 2018 Global Status Report*. Paris: REN21 Secretariat. ISBN 978-3-9818911-3-3.

Renewable Energy World. 2018. IEA: World Could Install 1.3 TW of Clean Energy by 2023, October 15, 2018. https://www.renewableenergyworld.com/articles/2018/10/iea-world-could-install-13-tw-of-clean-energy-by-2023.html.

Reuters Business. 2018. France's EDF Halts Four Nuclear Reactors Due to Heatwave, August 18, 2018. https://uk.reuters.com/article/uk-france-nuclearpower-weather/frances-edf-halts-four-nuclear-reactors-due-to-heatwave-idUKKBN1KP0EV.

Reuters Environment. 2019. Renewables Overtake Coal as Germany's Main Energy Source.https://www.reuters.com/article/us-germany-power-renewables/renewables-overtake-coal-as-germanys-main-energy-source-idUSKCN1OX0U2.

Samet, J.M. and Seo, J. 2016. The Financial Costs of the Chernobyl Nuclear Power Plant Disaster: A Review of the Literature. *USC*, 2016. https://uscglobalhealth.files.wordpress.com/2016/01/2016_chernobyl_costs_report.pdf.

Schiellerup, P. and Atanasiu, A. 2011. Innovations for a Low-Carbon Economy: An Overview and Assessment of the EU Policy Landscape—An IEEP Report for WWF-Sweden: Final Report 1 April 2011. http://www.climatesolver.org/sites/default/files/reports/110401.pdf.

Schneider, M., Froggatt, A., Hazemann, J., Katsuta, T., Ramana, M.V., Stirling, A., Johnstone, P., von Hirschhausen, C. and Wealer B. 2018. The World Nuclear Industry Status Report 2018, Mycle Schneider Consulting, Paris, 2018.

Schwägerl, C. 2011. Germany's Unlikely Champion of a Radical Green Energy Path. *Yale Environment 360*, University of Yale, School of Forestry and Environmental Studies.

Shinbun. 2018. Ex-IEA Official: Nuclear Power Can't Compete with Solar Power, July 24, 2018. http://www.asahi.com/ajw/articles/AJ201807240045.html.

Sovacool, B. 2008. Valuing the Greenhouse Gas Emissions from Nuclear Power: A Critical Survey. *Energy Policy* 36(8): 2940–2953.

Sovacool, B.K. and Ramana, M.V. 2014. Back to the Future: Small Modular Reactors, Nuclear Fantasies, and Symbolic Convergence. *Sage Journals, Science, Tech and Human Values*. https://doi.org/10.1177/0162243914542350.

Stewart, A. and Kneale, G. 2000. A Bomb Survivors: Factors that May Lead to a Re-assessment of the Radiation Hazard. *International Journal of Epidemiology* 29: 708–714.

Stirling, A. 2011. *Neglected Nuclear Lessons, STEPS (Social, Technological and Environmental Pathways to Sustainability)*. University of Sussex.

Stirling, A. 2014. Transforming Power: Social Science and the Politics of Energy Choices. *Energy Research & Social Science* 1: 83–95. ISSN 2214-6296.

Stirling, A. and Johnstone, P. 2018. A Global Picture of Industrial Interdependencies Between Civil and Military Nuclear Infrastructures, SPRU (Science Policy Research Unit), University of Sussex, SWPS 2018-13 (August) SPRU Working Paper Series (ISSN 2057-6668).

Spix, C., Schmiedel, S., Kaatsch, P., Schulze-Rath, R. and Blettner, M. 2008. Case-control Study on Childhood Cancer in the Vicinity of Nuclear Power Plants in Germany 1980–2003. *European Journal of Cancer* 44: 275–284.

SRU (German Advisory Council on the Environment). 2011. *Pathways Towards a 100% Renewable Electricity System: Summary for Policy Makers*. Berlin: SRU.

Texas Institute. 2011. Impact of Nuclear Power Projects on Credit Ratings and Creditor Recoveries Following Default of Investor Owned Utilities Sponsoring Nuclear Projects, Research Study, September 1, 2011, Texas Institute.

Toke, D. (2018). *Low Carbon Politics: A Cultural Approach Focusing on Low Carbon Electricity*. Abingdon, Oxon: Routledge.

Vaughan, A. 2019. Hitachi Scraps £16bn Nuclear Power Station in Wales. *The Guardian*. https://www.theguardian.com/business/2019/jan/17/hitachi-set-to-scrap-16bn-nuclear-project-anglesey-wales.

Versicherungsforen Leipzig GmbH. 2011. Calculating a Risk-appropriate Insurance Premium to Cover Third-party Liability Risks that Result from Operation of Nuclear Power Plants, Commissioned by the German Renewable Energy Federation (BEE), Günther, B., Karau, T., Kastner, E.M. and Warmuth, W., Leipzig, 1 April 2011.

Vidal, J. 2018. What Are Coastal Nuclear Plants Doing to Arrest Climate Change? *Ensia*. https://ensia.com/features/coastal-nuclear/.

Vienna Declaration. 2011. Declaration, May 25, 2011, Vienna, Ministers and Heads of Delegations of Austria, Greece, Ireland, Latvia, Liechtenstein, Luxembourg, Malta and Portugal, Lebensministerium.

WENRA Task Force (Western European Nuclear Regulators Association Task Force). 2011. 'Stress Tests' Specifications, Proposal by the WENRA Task Force, 21 April 2011.

WNN (World Nuclear News). 2018. Olkiluoto 3 EPR Parties Agree Settlement. *WNN*, March 12, 2018. http://www.world-nuclear-news.org/Articles/Olkiluoto-3-EPR-parties-agree-settlement.

Wood, G. 2018. Policy Risk, Politics and Low Carbon Energy. In: Considine, J.I. and Paik, K-W. (Eds.) *Handbook of Energy Politics*. Edward Elgar.

World Nuclear Association (WNA). 2015. Facilitating International Licensing of Small Modular Reactors, Cooperation in Reactor Design Evaluation and Licensing (CORDEL) Working Group of the World Nuclear Association, August 2015.

World Nuclear Association (WNA). 2017. Nuclear Power Economics and Project Structuring—2017 Edition Produced by: World Nuclear Association Published: January 2017 Report No. 2017/001.

World Nuclear Association (WNA). 2018. Poland Needs Nuclear to Reduce Emissions and Create Jobs. *WNA*, November 2018. http://www.world-nuclear.org/press/press-statements/poland-needs-nuclear-to-reduce-emissions-and-c.aspx.

Yoshimoto, Y., Yoshinaga, S., Yamamoto, K., Fijimoto, K., Nishizawa, K. and Sasaki, Y. 2004. Research on Potential Radiation Risks in Areas with Nuclear Power Plants in Japan: Leukaemia and Malignant Lymphoma Mortality Between 1972 and 1997 in 100 Selected Municipalities. *Journal of Radiological Protection* 24: 343–368.

4

Capacity Remuneration Mechanisms: Regulatory Tools for Sustaining Thermal Power Plants and the EU Energy Transition

Taner Şahin

1 Introduction

This chapter[1] aims to discuss why sustaining the profitability of thermal power plants (TPPs) is critical for the process of Energy Transition. Within the context of this chapter, TPPs are defined as power plants that generate electricity from fossil fuels including coal and natural gas. At first glance, this argument can be supposed to be irrational. It is truly ironic that Energy Transition, which is a precursor of a world with low or zero-carbon emissions, requires TPPs to proceed in a healthy manner. Since electricity, for now, is a product that cannot be stored economically at a sufficient level and renewable energy sources (RESs) such as wind and solar power cannot provide continuous electricity (intermittency problem), it seems TPPs will continue to maintain their importance as a back-up capacity to ensure generation adequacy (also called *resource adequacy*). Generation adequacy can be defined as the ability of capacity resources including supply side and demand side resources to meet aggregate demand in the long run (Table 4.1). Generation adequacy is a sub-concept

[1] This chapter is based on research carried out during the author's PhD thesis: Şahin, T. (2018) 'Capacity Remuneration Mechanisms In Energy-Only Markets: In Pursuit Of Creating A Regulatory Framework For The Integration Of Capacity Remuneration Mechanisms In The European Union Electricity Markets', University of Dundee, PhD Thesis (Unpublished).

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Table 4.1 Classification of reliability of electricity supply

Umbrella term	Classification	Definitions	
Reliability	Security	Security is the short-term component of the concept of reliability. It shows the endurance of an electricity system to any unexpected shocks and sudden disruptions.	
	Firmness	Firmness is a concept that cover the mid to long term. It basically deals with the supply of already installed generation capacity efficiently.	
	Adequacy	*Generation adequacy*	The ability of resources including both supply and demand side resources to meet total demand in the long-term. With an increasing share of intermittent RESs in the generation mix, *flexibility* as the new component of the definition of generation adequacy has become prominent in recent years. Flexibility, in short, is the ability of an electricity system to meet electricity demand and the variable electricity generation of RESs.
		Network adequacy	Electricity markets are network-bound markets. Therefore, reliability is not only related to adequate generation capacity; adequate levels of network investment are also vital so as to reach electricity from production points to consumption points. With this understanding, network adequacy can be defined as the ability of an electricity system that can ensure electricity from generators to consumers through adequate network capacity.

Source: Adapted from Şahin (2018: 44–55). Since this chapter is fundamentally about generation adequacy, other concepts such as security are out-with the scope of this chapter. This table is provided for terminological clarification. It should be kept in mind that all these concepts introduced on this table are closely interrelated in real life

of reliability of electricity supply, which is an umbrella concept that covers from short term (*security*) to long term (*firmness* and *adequacy*) aspects of reliable electricity supply. The revolutionary transformation in electricity markets witnessed in the last decade has made flexibility the essential part of the definition of generation adequacy. Indeed, as noted by Henriot and Glachant (2015: 40):

> […] a large share of the resources remunerated will have to operate in a flexible way, so as to cope with the variability of intermittent RES. In this context, generation adequacy […] is not only about securing a minimum reserve margin, but also about delivering an adequate flexibility mix for the system. Part of the

> incentives to promote generation flexibility […] might be embodied in short-term energy prices, but it is clear that the issue of generation adequacy cannot be completely separated from the issue of flexibility.

With increasing intermittent RESs in electricity markets, the issue of flexibility has been regarded as a problem to ensure generation adequacy. Flexibility is the ability of an electricity system to meet both the electricity demand and variable electricity generation of RESs (see Table 4.1). Flexibility is a product that can be provided at various levels by various sources including demand and supply side sources. A number of scholars including Haas et al. (2013: 131–132), Ela et al. (2014: viii) and Henriot (2015: 14) have rightly indicated that increasing intermittent RESs within generation mixes around the world simultaneously increases the need for flexibility which is properly supplied by TPPs, particularly gas power plants, and well-designed demand-side response programmes. The increasing need for flexibility is fundamentally related to the intermittency problem becomes apparent with increasing shares of RES in generation mixes, particularly in developed countries such as EU Member States. The intermittency problem stems from three basic characteristics of these resources: (1) Intermittent RESs are variable because their electricity output depends on weather conditions; (2) Supply of RESs are uncertain because their electricity output is unclear until the real time; and (3) These intermittent RESs are location-specific because the potential of wind and solar power are not technically necessary to be situated close to demand centres (Kondziella and Bruckner, 2016: 11). So, with these characteristics, integrating intermittent RESs into electricity markets requires more flexible capacity resources.

It is known that liberalisation in electricity markets created challenges to ensure generation adequacy. The process of Energy Transition, the impact of which has become increasingly felt in recent years, further complicates the issue of generation adequacy in energy-only markets. In this regard, the role of Capacity Remuneration Mechanisms (CRMs) becomes even more prominent in Energy Transition. This chapter essentially aims to reveal the role of CRMs to sustain TPPs and, hence, promote Energy Transition. For this purpose, the concept of Energy Transition is analysed within the context of increasing share of RESs and changing roles of TPPs in electricity markets. Then, the emergence of CRMs is examined. In concluding, an answer is given to the question of why properly designed CRMs should be part of electricity markets as bridges[2] to sustain both TPPs and the Energy Transition.

[2] To the best of our knowledge, the analogy between CRMs and bridges was first made by Gonzalez-Diaz in the following source: Gonzalez-Diaz (2015).

2 Energy Transition, Generation Adequacy and Changing Role of Thermal Power Plants

2.1 What is the Energy Transition?

In recent years, the majority of research on European electricity markets have appropriately felt the need to highlight the point that there is a major transition process on-going in energy markets. Certainly, the question of what this huge transition is has no easy answer. Energy Transition may have different meanings for different countries or different timeframes. Transition as a word can be defined as "a change from one form or type to another, or the process by which this happens."(Cambridge Dictionary, n.d.). By their nature, all kinds of transitions, including Energy Transitions, create challenges to be overcome. This is natural because all transitions, more or less, must aim to change a kind of status quo. It is a well-known fact that one of the primary features of any status quo is their resistance to changes/transitions. So, it can be argued that Energy Transition as a form of major transformation aims to change the current status quo in the energy sector based on mainly fossil-fuel inputs with a highly centralised structure to a low carbon and decentralised structure. In this sense, it is important to define the concept of Energy Transition.

Some researchers and institutions have attempted to define it. For instance, Smil (2010: vii) argued that even though there is no commonly accepted definition of the concept of Energy Transition, it is mainly described as "the change in the composition (structure) of primary energy supply". Further, Mersinia and Penttinen (2017: 1) defined this concept as a process "that the energy system is required to undergo in order to meet the challenges posed, in particular, by the man-made greenhouse gases attributable to the energy sector". In a similar way, Arent et al. (2017: 3) indicated that the notion of Energy Transition widely means the replacement of current technologies and related energy inputs throughout all energy industries both at the levels of intermediates and final goods. Furthermore, in one of its reports, the World Energy Council (WEC) (Hauff et al., 2014: 2) defined Energy Transition as a fundamental structural change of the energy industry occurring around the world without any exception. European electricity markets are experiencing the challenging consequences of this paradigm-shift transition, largely prior to the rest of the world's electricity markets. This reality is best expressed in the World Energy Outlook 2016 (International Energy Agency (IEA), 2016b: 272): "*The speed and depth of the projected transition to new renewable energy* *sources in power generation in the EU makes it a living laboratory for other large economies seeking to ramp up variable renewable generation, including China and the United States*" The rapid proliferation of CRMs across Europe can be regarded as a natural part and/or consequence of this transition.

Unquestionably, the concept of Energy Transition covers much wider issues but, within the context of this chapter, it is here embraced in terms of the increasing share of intermittent RESs in generation mixes.

2.1.1 The Rise of Intermittent RESs in Electricity Markets

As can be seen in Figs. 4.1 and 4.2 below, the proportion of wind and solar power in generation mixes have dramatically increased in most jurisdictions around the world over the last decade.

Furthermore, within the EU context, intermittent RESs are expected to correspond to around 94% of total electricity demand in Denmark, 63% in Ireland, and 53% in the UK by 2030 (Haas et al., 2013: 131). The highly ambitious 2030 targets (at least 40% reduction in domestic greenhouse gas emissions, at least 27% improvement in energy efficiency and at least 27% renewables share of total electricity consumption at the EU level) set out by the European Council in October 2014 will further increase the share of intermittent RESs in Member States' generation mixes, estimated to reach up to 50% of electricity generation (European Commission, 2015: 3).

The EU regulatory framework for electricity markets has always given special attention to RESs to decarbonise electricity markets. It binds Member States to develop support schemes to increase the share of RESs in general electricity consumption (*Directive 2009/28/EC*, Article 3). In line with this

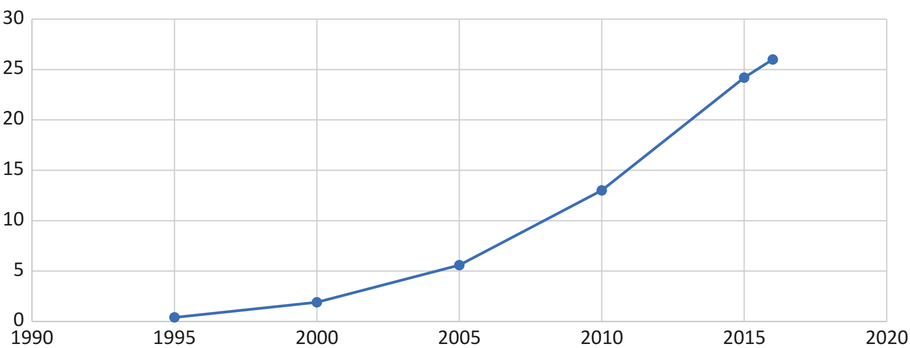

Fig. 4.1 Solar and wind energy—cumulative capacity—share of total—1990–2016 (%). (Source: Adapted from European Commission, 2018a: 96)

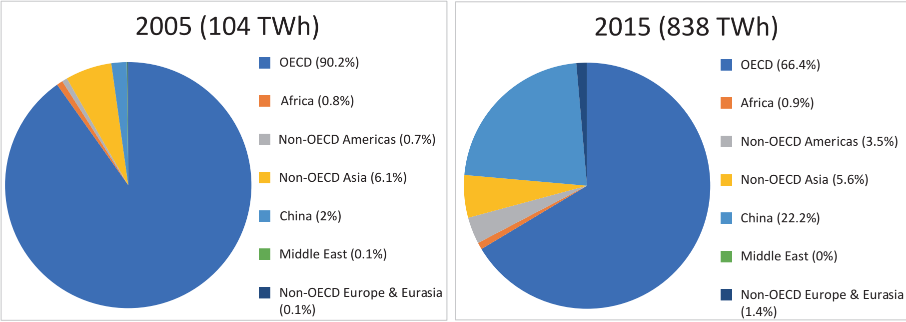

Fig. 4.2 Regional shares of wind electricity production (2005 and 2015). (Source: Adapted from IEA, 2017a: 22)

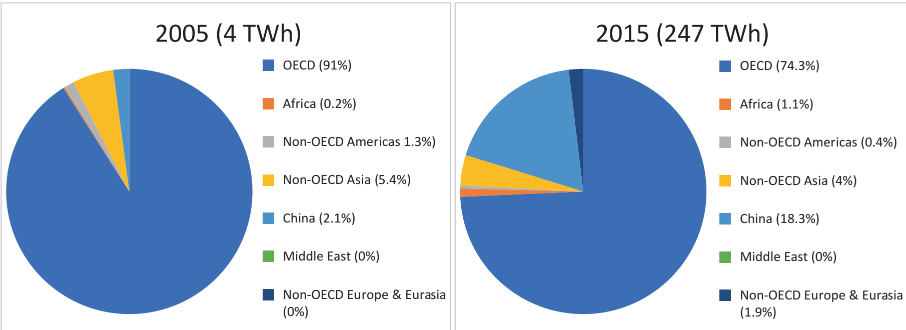

Fig. 4.3 Regional shares of solar PV electricity production (2005 and 2015). (Source: Adapted from IEA, 2017a: 24)

binding rule, Member States have developed a range of support schemes for RESs. In company with the increasing utilisation of RESs in electricity generation, the policy of supporting intermittent generation has achieved outstanding success in Europe (Ragwitz et al., 2011: 8). Figure 4.3 below illustrates how this success has evolved in the 28 EU Member States between 1990 and 2016.

Another estimation suggests that the percentage of RESs in electricity generation within the EU will rise from 21% in 2010 to 34–36% by 2020 (Haas et al., 2013: 125). For instance, in Germany, the share of RESs in generation is expected to reach 42% by 2020, of which the largest proportion of this increase belongs to offshore and onshore wind (Bauknecht et al., 2013: 171). Of course, these successes have an alternative cost for European electricity markets, particularly in terms of generation adequacy. These statistics and expectations reveal that generation adequacy concerns will be even worse in both Europe and the world due to the rise of intermittency. The rising share of intermittent RESs in generation mixes has created a new kind of challenge called flexibility for ensuring generation adequacy.

When the share of intermittent RESs was marginal in general electricity consumption, the focus was on how to promote RESs in an effective and efficient way (Bauknecht et al., 2013). However, this focus has shifted to the question of how rising intermittency in electricity markets affect the whole electricity system (Bauknecht et al., 2013). Given the rising share of RESs in general electricity consumption, the risks faced by TPPs are now considerably different to those they faced in the past. Meyer et al. (2014: 2–3) showed two outcomes of the rising share of RESs: First, the increasing share of RESs produces merit order effect which pushes TPPs, especially gas-power plants, out of merit order; and, second, constraints on the operating hours of existing TPPs means that they run far less frequently than before. In the literature, the effect of RESs on the operating hours of TPPs is known as the merit-order effect, which means that as the share of RESs increases in generation mix, it pushes TPPs in the right direction on merit order (Sensfuß et al., 2008; Nicolosi and Fürsch, 2009).

2.1.2 Why Intermittent RESs Cannot Ensure Generation Adequacy?

The reason why intermittent RESs exacerbate generation adequacy concerns is that neither wind nor solar power can supply firm capacity and they can therefore substitute only a small part of conventional generators such as coal and gas plants (Cramton et al., 2013: 40). Firm capacity can be defined as the amount of energy that must be guaranteed to be available at a given time (Energyvortex.com, n.d.). Moreover, intermittent RESs increase price volatility, reduce general price levels and deteriorate the capacity utilisations of TPPs (Cramton et al., 2013). In line with this argument, Bauknecht et al. (2013: 191) explained the detrimental effect of intermittent RESs for generation adequacy from two perspectives: (1) The dominance of intermittent RESs in electricity markets increases the unpredictability of supply. The higher the share of intermittent RESs, the more vital it is to deliver for adequate volumes of reliable backup or storage capacity to overcome the risk of a gap in RES supply; and (2) With an increasing share of RESs, the utilisation rates of TPPs decrease, leading to even higher peak prices to compensate for investment costs.

In one of its reports, the IEA puts forward that intermittent RESs including solar and wind have five basic differences from TPPs (IEA, 2016a: 20): (1) Their generation levels fluctuate depending on the real time availability of sun and wind; (2) These fluctuations can only be forecasted with remarkable success for a few hours ahead, although some fairly accurate predictions can be made a few days in advance; (3) Their connection to the grid needs a different type of technology called converter technology which is relevant especially in terms of electricity system stability, for instance, after an unforeseen shutdown of a generator; (4) They exhibit a much larger footprint (in terms of size of the power plant) in comparison to TPPs, and are located at a considerable distance from each other again in comparison to conventional power plant; and (5) Unlike fossil-based energy sources, these resources cannot be transported, and the siting (location) of such plant where they can attain the best level of availability are typically far from consumers. In terms of this chapter, the first two differences regarding intermittent RESs are more relevant since these differences indicate the lower level of reliability of these resources when compared to TPPs. The reason behind this is that the firm capacity of intermittent RESs is considerably low, which makes these sources less reliable. As noted by Haas et al. (2013: 130), large intermittent RESs capacity investments do not automatically convert into generation owing to the lower capacity factors of wind and solar powers; that is, a normal wind farm may work around 1,800–2,300 hours in a year while a solar power generator may work about 800–1,200 hours in a year, depending on the location. Here, capacity factor can be defined as the percentage of average working hours of a power plant in a year (IEA, 2017b: 10).

For instance, while the capacity factor of a solar power plant lies between 10–30%, wind plants' capacity factor ranges between 20–50% (IEA, 2017b). Therefore, according to an analysis, each MW of wind capacity commonly needs 1 MW of back-up capacity to guarantee 90% availability (Cailliau et al., 2010: 8). Of course, since electricity systems are not mostly island systems, the argument of "*1 MW wind capacity needs 1 MW back-up*" can be changed through increasing interconnections, developing storage facilities including pump hydro storage, district heating systems, electric vehicles and demand side management mechanisms such as interruptible supply contracts (Cailliau et al., 2010). However, it is still a true fact that intermittent RESs need a high level of back-up capacity. In another study, it was stated that "*the level of firmness* […] *of intermittent energy sources is quite limited (5–10% maximum) which means that they can be considered as energy sources but not as capacity suppliers*." (Cailliau et al., 2011: 12). Furthermore, the same study provides a stunning example:

> [A] system with a peak demand of 40,000 MW, and without any intermittent RES capacity, would require 44,000 of installed conventional capacity with high level of firmness to guarantee a 10% reserve margin over peak demand. If the same system included 20,000 MW of wind with a capacity credit of 2,000 MW (10%), then there would still be a need for 42,000 MW of conventional firm capacity to guarantee the 10% reserve margin—i.e. hardly less conventional capacity than in the previous system without wind generation. (Cailliau et al., 2011: 12)

Of course, these calculations about back-up capacity requirement for intermittent RESs can vary from situation to situation. For instance, the IEA notes that capacity credits of intermittent RESs are changed based on different factors such as season, location, and generation mix (IEA, 2017b: 10). However, at the end of the day, it is clear that these sources are considerably less reliable than TPPs.

2.2 Changing Role of Thermal Power Plants: From Base-load to Flexibility Providers

Once upon a time, TPPs including coal and gas power plants were designed and established to serve as base or mid load plants. But this situation has been fundamentally changed in recent years through the increasing growth of intermittent RESs in Europe. The profitability of TPPs has substantially decreased in recent years. On this issue, Vanderberghe and Gonne (2015: 244) claimed that because of generously supported intermittent RESs and its damaging effect for particularly large scale and flexible gas power plants, a new type of missing money problem has occurred. To give some concrete examples, between 2008 and 2013, the average utilisation of TPPs decreased from 50% to 37% due to massive increases in renewable energy investments as well as the world-wide economic crisis (Coibion and Pickett, 2014: 3). Caldecott and McDaniels (2014: 5) showed that base-load plants, including especially gas power plants, built with the expectations of high running hours had continuously low or even negative spark spreads because of their declining running hours in line with the increasing share of renewable energy sources. According to the Special Report on World Energy Investment Outlook 2014 prepared by the IEA (2014: 113), the 20 largest publicly listed EU utilities lost about 85% of their combined net income between 2009 and 2013. As a result of decreasing operating hours, competitive coal prices, low carbon and wholesale electricity prices, even high-efficiency gas power plants have not been able to reimburse their capital costs since 2011 (IEA, 2014: 114). Hence, many TPPs in Europe have decided to mothball or permanently retire earlier than their capital costs are recovered. For instance, it is said that 24 GW of thermal power plant in the EU was mothballed and 7 GW decommissioned in 2013 (Coibion and Pickett, 2014: 3). In the same direction, Caldecott and McDaniels (2014: 12) have argued that ten utilities in the EU declared the mothballing or closure of 20.08 GW of gas-power plants in 2012–2013 alone.

Contrary to the facts above, the importance of TPPs, especially gas-power plants, is gradually increasing due to the fact that these power plants provide flexibility which is a vital product in such electricity markets dominated by intermittent electricity sources rather than TPPs. Gonzalez-Diaz (2015: 5–7) argued that the rising share of RESs in generation mixes pushes TPPs out of merit-order; however, since RESs cannot provide reliable electricity, TPPs must be in the system as a back-up and flexible capacity source to ensure generation adequacy. In other words, TPPs have become indispensable elements of the Energy Transition due in large part to the flexibility that they can provide.

3 Critical Bridges of EU Energy Transition: Capacity Remuneration Mechanisms

Until now, the discussion has focused on the issues of why the profitability of TPPs have decreased and why they are critical for generation adequacy in the process of Energy Transition. At this point, an important question comes up: How can the economic life of TPPs be maintained? Unquestionably, more than one method can be developed to increase or maintain the profitability of TPPs. CRMs are one such methods. Within the context of this chapter, CRMs are analysed below as a way of keeping TPPs online in electricity markets during Energy Transition.

3.1 What are Capacity Remuneration Mechanisms?

CRMs are regulatory tools to provide incentive-based guarantees for investors to help their long-term investment decisions. These tools manage and coordinate new investment decisions to attract new capacity resources and guarantee that adequate generation capacity will be available when they are needed at any time (Ausubel and Cramton, 2010: 195). According to Ausubel and Cramton (2010: 195), these markets can solve three basic problems: market power, risk, and investment. In this sense, it can be said that the basic purpose of all types of CRMs is to attract adequate investment for generation adequacy in the long-run. Before liberalisation, there was virtually no concern regarding who will ensure generation adequacy in electricity markets. In a vertically integrated electricity market structure, reliability was monitored via centralised planning. Hence, there was no need to deal with the different dimensions of reliability mentioned above (see Table 4.1) separately and there was no requirement to think about the issue of responsibility. Liberalisation, nonetheless, has brought about a new challenge regarding the ability of markets to ensure long-term generation adequacy. As the process of liberalisation has continued, responsibility between states and markets regarding generation adequacy have become gradually vague.[3] A significant number of scholars including Besser et al. (2002), De Vries and Hakvoort (2004), Joskow (2006), De Vries (2007), Finon and Pignon (2008), Ausubel and Cramton (2010) and Rodilla and Batlle (2013) analysed this issue. All of them, more or less, agreed that several market imperfections which characteristically pertain to electricity markets prevent energy-only markets from providing sufficient generation adequacy. These market imperfections can be summarised as the missing money problem, market power and entry barriers, the boom-and-bust cycle problem, lack of long-term contracts and inelastic demand structure. In addition to these economic-based realities mentioned above, Besser et al. (2002: 53–54) called attention to the political economic dimension of electricity markets, noting that "[u]*nfortunately, given the level of effort that has been expended, the question of the need for, desirability, and/or appropriateness of capacity obligation as a separate element of a competitive electricity market cannot be answered solely through economic theory*". It is a well-known fact that electricity as a public utility is not generally seen as a standard commodity or service, because a dramatic price rise or a sudden blackout or other failures in electricity markets can adversely affect the political position of politicians, unsurprisingly more so than for other sectors. On this point, Rodilla and

[3] For further discussion regarding how liberalisation have affected the responsibility between states and markets and definitions of energy security of supply, see Cameron, P.D. 2007. *Competition in Energy Markets: Law and Regulation in the European Union*. New York: Oxford University Press; Egenhofer et al. (2004). *Market-Based Options for Security of Energy Supply*. http://host.uniroma3.it/dipartimenti/economia/pdf/FEEM_117-04.pdf; Jamasb, T. and Pollitt, M. 2008. Security of Supply and Regulation of Energy Networks. *Energy Policy* 36: 4584–4589; de Jong, J., Maters, H., Scheepers, M. and Seebregts, A. 2006. *EU standards for Enegy Security of Supply*. https://www.ecn.nl/docs/library/report/2006/c06039.pdf; Lieb-Dóczy, E., Börner, A.R. and MacKerron, G. 2003. Who Secures the Security of Supply? European Perspectives on Security, Competition, and Liability. *Electricity Journal* 16: 10–19; Rutherford, J.P., Scharpf, E.W. and Carrington, C.G. 2007. Linking Consumer Energy Efficiency with Security of Supply. *Energy Policy* 35: 3025–3035; Sauter, W. and Schepel, H. 2009. *State and Market in European Law: The Public and Private Spheres of the Internal Market before the EU Courts*. Cambridge: Cambridge University Press; Wright, P. 2005. Liberalisation and the Security of Gas Supply in the UK. *Energy Policy* 33: 2272–2290.

Batlle (2012: 182–183) rightly drew attention to politicians' risk aversion regarding electricity markets in which any shortage of electricity, as an essential good, may have significant social and political outcomes.

Due to market imperfections and the risk averse characteristic of politicians indicated above, several types of CRMs have been developed to date. In broad terms, they can be grouped depending on whether they are price-based or quantity-based. Quantity-based mechanisms can be further classified as market-wide or targeted mechanisms (Table 4.2).

Table 4.2 Taxonomy of CRMs

Price/Volume based	Types of CRMs	Definition
Price based	Capacity payments	This is a price-based measure in which capacity providers get a fixed amount of payments in addition to revenues earned from energy sales in the market. The amount is determined by an independent authority in the expectation that it enhances the incentives to attract new investment and/or maintain existing capacity. Capacity payments can be designed as market-wide or targeted.
Volume based	Strategic reserves	This is a targeted measure in which contracted capacity is set aside and only bid into market when the market cannot cover the demand.
	Reliability options	This is a market-wide measure. Roughly speaking, reliability options are similar to call options contracted through centralised auction. Capacity providers that have reliability options must pay the difference between spot price and strike price (determined by an independent authority) whenever this difference is positive.
	Capacity obligations	This is a market-wide and decentralised measure where obligations are imposed on suppliers to contract for capacity which should be higher than their expected or contracted consumption or supply obligations to a certain level. Contracted parties must make the contracted capacity available during scarcity periods, defined by an administrative body or market prices.
	Capacity auctions	This is a market-wide mechanism in which total required capacity determined by an independent authority is procured through a centralised auction. Capacity auctions can be conducted year-by-year or for forward capacity. Contracted parties must make the contracted capacity available in compliance with the terms of the contract.

Source: Agency for the Cooperation of Energy Regulators (ACER) (2013b), Barth et al. (2014), Tennbakk et al. (2013), Şahin (2017)

3.2 The Story of Capacity Remuneration Mechanisms in the EU

The story of CRMs in the EU mainly started at the beginning of this decade. Of course, this does not mean that there were no previous discussions regarding CRMs in any Member States. Capacity payments as a type of CRM has been implemented in different EU countries such as the UK, Spain, Portugal, Italy and Ireland at different times over the last decades. Liberalisation and increasing integration in European electricity markets has revealed new challenges for generation adequacy (European Commission, 2013: 2). Contrary to popular belief, rising concerns regarding generation adequacy in the EU are not primarily about shrinking reserve capacity (or, capacity margin) in electricity supply. For instance, in 2013, the margin was highest in Denmark, Spain, Italy and Portugal while it was smallest in Belgium, Croatia, Poland and Sweden (European Commission, 2016: 16). However, the level of reserve margin itself does not show that generation adequacy can be ensured without any challenges. At this point, the missing money problem, as in other parts of the world, appears as the main cause of the increasing generation adequacy concerns in the EU. Additionally, a range of interrelated policy developments including the rising share of intermittent RESs in Member States' generation mixes, low carbon prices, decreasing growth of electricity demand due to the world-wide economic crisis, the competitive advantage of coal against natural gas and low wholesale electricity prices (23% below than needed in 2013) (IEA, 2014: 91) have exacerbated the missing money problem. Some authors (Coibion and Pickett, 2014: 2; Roques, 2014: 79) define the combined effect of these policy developments as a "*perfect storm*". It can be discussed that among these policy developments that ignited the missing money problem, the increasing share of intermittent RES in Member States' energy mixes seems the most serious challenge that should be overcome. Other challenges mentioned above can be seen as cyclical or can be solved through some relatively easier regulatory changes; however, intermittent RESs cause mainly structural problems.

Due to the abovementioned perfect storm, many researchers (Bauknecht et al., 2013: 185; Haas et al., 2013: 143; Keay et al., 2013: 55; Newbery, 2013: 10; Glachant and Ruester, 2014: 1) have noted that the current electricity market structure is not sufficient to maintain a certain level of security of supply. For instance, although Glachant and Ruester (2014: 1) emphasised the achievements of the liberalisation movement in EU Electricity Markets in recent decades, they also argued that unexpected developments in the EU Electricity Markets such as an increasing share of intermittent RESs, decreasing working hours of TPPs while increasing needs for flexibility and decentralisation of electricity generation have created tough challenges that the current electricity market design of the EU cannot overcome. Similarly, Keay et al. (2013: 55) argued that:

> […] existing markets will not generate the level of and types of investment which many governments are aiming at. It is difficult for those governments to find market-friendly measures to guide investment; low-carbon generation tends to be unattractive to investors because of its inflexibility, high levelized costs, and capital intensity.

Not only academic papers but also reports prepared by national and supranational institutions have highlighted the inadequacy of current electricity markets against emerging challenges. In its press release, Office of Gas and Electricity Markets (OFGEM) (2010: 1) indicated that "[t]*he unprecedented combination of the global financial crisis, tough environmental targets, increasing gas import dependency and the closure of ageing power stations has combined to cast reasonable doubt over whether the current energy arrangements will deliver secure and sustainable energy supplies*". Similarly, the Agency for the Cooperation of Energy Regulators ACER (2013a: 8–9) noted that energy-only markets could deliver generation adequacy if electricity prices in the market were allowed to move freely in compliance with the law of supply and demand, that demand was able to respond to short-term price signals and, at scarcity times, prices could rise up to the level of value of lost load (VOLL) as well as a stable policy and regulatory regime would give confidence to investors. Actually, ACER (2013a) here repeats what the theory says. However, after saying this, ACER (2013a) stated that it is aware that, under the current situation, these conditions may not always be met because of the two reasons set forth below (ACER, 2013a: 9):

- There is a considerable intervention in power pricing by putting price caps implicitly or explicitly, as continued high prices and frequent price spikes may be politically unacceptable.
- There is a limited demand-side participation although different regulatory frameworks and technics can be put in place to foster it.

Therefore, ACER (2013a: 9) indicated that:

> [I]n practice, as long as the conditions outlined above are not met, there is no guarantee, even once the EU electricity market integration process is completed, that energy-only market will be able by itself to deliver the required level of resource adequacy and system flexibility.

Due to these reasons, a great number of Member States have established some kinds of CRMs in their jurisdictions for the sake of generation adequacy since the beginning of this decade.

3.3 Why are Capacity Remuneration Mechanisms Bridges of the EU Energy Transition?

It was argued above that energy-only markets may not address generation adequacy concerns. Energy Transition have exacerbated generation adequacy concerns. Therefore, many types of CRMs have been established in the EU countries since the first half of this decade. There is no uncertainty that CRMs are directly related to ensuring generation adequacy. The main reason for the establishment of CRMs is to attract adequate new capacity investment or to sustain existing capacity resources enough profitable in order to keep the lights on in the long run.

TPPs, which have had enough reasons to complain about decreasing profitability even under the conditions of energy-only markets, need to develop alternative business models in the atmosphere of uncertainty brought by the process of Energy Transition. Indeed, the economic bottleneck in which TPPs are increasingly continues. According to Waldron and Nobuoka (2017), Energy Investment Analysts at the IEA, "[r]*ecent financial performance of European utilities reflects these trends. In 2017, the aggregate earnings of the top twenty utilities likely continued to decline, to around 35% lower than in 2012*". In a similar vein, the European Commission (2018b: 2) indicated in its Quarterly Report on European Electricity Markets (first quarter of 2018) that despite declining coal and steady gas prices, profitability of gas and coal power plants further worsened in Q1 2018 in many EU Member States. Additionally, the second quarter of the same report (European Commission, 2018c: 2) noted that "*coal and gas consumption in power generation in the EU fell further in Q2 2018, as increasing coal, gas and carbon prices did not contribute to any improvement in the profitability of fossil fuel technologies*". Under these circumstances, then, it is not difficult to predict that the economic situation of TPPs will not change for the better if indeed it does not worsen. So, a wait-and-see attitude can be devastating for TPPs which, as discussed, have a critical importance in the process of Energy Transition. For this reason, the existence and development of CRMs is vital for both TPPs to sustain their economic lives and for the process of Energy Transition to proceed in a healthy manner. On this issue, when Michael Pollitt, one of the most distinguished experts in electricity markets, said that "[…] *by providing support for fossil fuel capacity,*

capacity markets allow EU countries to go higher percentages of renewable energy production"(Euractiv, 2018: 8). Further, he noted that "[…] *capacity markets have gone along with commitments to reduce fossil fuel energy shares. So this may be the price that we have to pay*" (Euractiv, 2018: 9).

It is understood that Energy Transition in electricity markets need TPPs, and TPPs need CRMs in order to increase the share of RESs without any anxiety concerning generation adequacy when there is no available solar or wind power (Euractiv, 2018,: 9). Therefore, there is a situation of mutual interdependence. Actually, CRMs in Europe seem to fit perfectly with the changing role of TPPs in such an electricity market structure dominated by intermittent RESs. This argument was neatly put into words by Bauknecht et al. (2013: 191), that in an electricity market led by RESs, the role of TPPs shifts from base load supply to becoming a capacity reserve so as to take action where RESs cannot supply adequate electricity. In this sense, as noted by Gonzalez-Diaz (2015: 30), CRMs can be seen as bridges of Energy Transition. Gonzalez-Diaz (2015: 30) indicated that CRMs "*take on board the fundamental task of bridging the EU environmental ambitions with security of supply*". It is obvious that without the bridges of CRMs, the huge waves created by Energy Transition may not be overcome.

4 Conclusion

This chapter has argued that TPPs are crucial elements of Energy Transition to provide flexibility which is increasingly important in electricity systems dominated by intermittent RESs. First, the question of what Energy Transition is was briefly analysed. This question was basically handled within the context of increasing shares of RESs in generation mixes. This chapter also examined why intermittent RESs cannot contribute to generation adequacy as much as TPPs. Within this understanding, the changing role of TPPs in the process of Energy Transition was addressed. Following these discussions, the issue of why CRMs have been established or are being established in Member States were thoroughly addressed. At the end of the discussion, it is concluded here that CRMs are bridges of Energy Transition that help the transformation of electricity markets from a centralised and mainly fossil-fuel based structure to a decentralised structure allowing RESs to dominate and consumers to participate. They are necessary to sustain TPPs and, hence, to reach the aims of Energy Transition including a low, if not zero, carbon future.

As a last but highly crucial word of this chapter, it should be stressed that CRMs are not and should not be there to support outdated, fruitless and environmentally hazardous TPPs, even for the sake of generation adequacy. On the contrary, CRMs should be designed as enablers of the process of Energy Transition. The role of enabler for CRMs is fundamentally dependent upon the ability and intention of their designers. As long as CRMs are designed in a friendly manner with Energy Transition clearly in mind, they will be one of the most vital elements of this critical process for electricity markets.

References

Agency for the Cooperation of Energy Regulators (ACER). 2013a. *Opinion of the Agency for the Cooperation of Energy Regulators No 05/2013: On Capacity Markets*. http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Opinions/Opinions/ACER Opinion 05-2013.pdf.

Agency for the Cooperation of Energy Regulators (ACER). 2013b. Capacity Remuneration Mechanisms and the Internal Market for Electricity. http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/CRMs%20and%20the%20IEM%20Report%20130730.pdf.

Arent, D. et al. 2017. Introduction and Synthesis. In: Arent, D., Arndt, C., Miller, M., Tarp, F. and Zinaman, O. (Eds.) *The Political Economy of Clean Energy Transitions*. Oxford: Oxford University Press.

Ausubel, L.M. and Cramton, P. 2010. Using Forward Markets to Improve Electricity Market Design. *Utilities Policy* 18: 195–200. https://doi.org/10.1016/j.jup.2010.05.004.

Barth, T., Géron, A-M., Lopes, P. and Noyens, K. 2014. Renewable Energy and Security of Supply: Finding Market Solutions. http://elyntegration.eu/wp-content/uploads/2014_RES_Supply_Market_eurelectric_Report.pdf.

Bauknecht, D., Brunekreeft, G. and Meyer, R. 2013. From Niche to Mainstream: The Evolution of Renewable Energy in the German Electricity Market. In: Sioshansi, P. F. (Ed.) *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*. Academic Press, pp. 169–198.

Besser, J.G., Farr, J.G. and Tierney, S.F. 2002. The Political Economy of Long-term Generation Adequacy: Why an ICAP Mechanism is Needed as Part of Standard Market Design. *Electricity Journal* 15: 53–62.

Cailliau, M. et al. (2010). *Integrating Intermittent Renewable Sources into the EU Electricity System by 2020: Challenges and Solutions*. https://www.researchgate.net/profile/Dr_Andreas_Poullikkas/publication/258402979_Integrating_intermittent_renewables_sources_into_the_EU_electricity_system_by_2020_challenges_and_solutions/links/00b7d52824c7dd07a0000000/Integrating-intermittent-renewables.

Cailliau, M. et al. (2011). RES Integration and Market Design: Are Capacity Remuneration Mechanisms Needed to Ensure Generation Adequacy? *Euroelectric*. https://www3.eurelectric.org/media/26300/res_integration_lr-2011-030-0464-01-e.pdf.

Caldecott, B. and McDaniels, J. 2014. *Stranded Generation Assets: Implications for European Capacity Mechanisms, Energy Markets and Climate Policy*. https://www.smithschool.ox.ac.uk/research/sustainable-finance/publications/Stranded-Generation-Assets.pdf.

Cambridge Dictionary. (n.d.) *Transition*. https://dictionary.cambridge.org/dictionary/english/transition.

Cameron, P.D. 2007. *Competition in Energy Markets: Law and Regulation in the European Union*. New York: Oxford University Press.

Coibion, A. and Pickett, J. 2014. *Capacity Mechanisms. Reigniting Europe's Energy Markets*. https://linklaters.de/fileadmin/redaktion/pdf/Linklaters Report_Capacity Markets.pdf.

Cramton, P., Ockenfels, A. and Stoft, S. 2013. *Capacity Market Fundamentals, Economics of Energy & Environmental Policy*. http://www.cramton.umd.edu/papers2010-2014/cramton-ockenfels-stoft-capacity-market-fundamentals.pdf.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA Relevance) (n.d.). Official Journal of the European Union.

Egenhofer, C., Gialoglou, K., Luciani, G., Boots, M., Scheepers, M., Costantini, V., Gracceva, F., Markandya, A. and Vicini, G. 2004. *Market-Based Options for Security of Energy Supply*. http://host.uniroma3.it/dipartimenti/economia/pdf/FEEM_117-04.pdf.

Ela, E., Milligan, M., Bloom, A., Botterud, A., Townsend, A. and Levin, T. 2014. *Evolution of Wholesale Electricity Market Design with Increasing Levels of Renewable Generation*. https://www.nrel.gov/docs/fy14osti/61765.pdf.

Energyvortex.com (n.d.). *Energy Dictionary: Firm Capacity*. https://www.energyvortex.com/energydictionary/firm_capacity__firm_energy__nonfirm_energy__firm_power.html.

Euractiv. 2018. *Capacity Markets for Electricity: Special Report*. https://en.euractiv.eu/wp-content/uploads/sites/2/special-report/EURACTIV-Special-Report-Capacity-markets-for-electricity.pdf.

European Commission. 2013. *Commission Staff Working Document Generation Adequacy in the Internal Electricity Market—Guidance on Public Interventions*. SWD(2013) 438 Final. Brussels.

European Commission. 2015. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Launching the Public Consultation Process on a New Energy Market Design*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0340&from=EN.

European Commission. 2016. *Commission Staff Working Document: Final Report of the Sector Inquiry on Capacity Mechanisms*. SWD(2016) 385 Final. Brussels.

European Commission. 2018a. *EU Energy in Figures—Statistical Pocketbook 2018*. https://publications.europa.eu/en/publication-detail/-/publication/99fc30eb-c06d-11e8-9893-01aa75ed71a1/language-en.

European Commission. 2018b. *Quarterly Report on European Electricity Markets (First Quarter of 2018)*. https://ec.europa.eu/energy/sites/ener/files/documents/quarterly_report_on_european_electricity_markets_q1_2018.pdf.

European Commission. 2018c. *Quarterly Report on European Electricity Markets (Second Quarter of 2018)*. https://ec.europa.eu/energy/sites/ener/files/documents/quarterly_report_on_european_electricity_markets_q2_2018.pdf.

Finon, D. and Pignon, V. 2008. Electricity and Long-term Capacity Adequacy: The Quest for Regulatory Mechanism Compatible with Electricity Market. *Utilities Policy* 16: 143–158.

Glachant, J.M. and Ruester, S. 2014. The EU Internal Electricity Market: Done Forever? *Utilities Policy* 30: 1–7.

Gonzalez-Diaz, F.E. 2015. EU Policy on Capacity Mechanisms. In: Hancher, L., De Hauteclocque, A. and Sadowska, M. (Eds.), *Capacity Mechanisms in the EU Energy Market: Law, Policy, and Economics*. 1st ed. Oxford University Press, pp. 3–31.

Haas, R., Auer, H., Resch, G. and Lettner, G. 2013 The Growing Impact of Renewable Energy in European Electricity Markets. In: Sioshansi, F.P. (Ed.), *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*. Boston: Academic Press, pp. 125–146.

Hauff, J., Bode, A., Neumann, D., Haslaur, F., Azevedo, C., Haischer, P., Hatrmann, B., Oswald, K., Santos, F., Sprott, M., Yong, T. and Zantout, R. 2014. *Global Energy Transitions: A Comparative Analysis of Key Countries and Implications for the International Energy Debate*. https://www.atkearney.com/documents/10192/5293225/Global+Energy+Transitions.pdf/220e6818-3a0a-4baa-af32-8bfbb64f4a6b.

Henriot, A. 2015. *Economics of Intermittent Renewable Energy Sources: Four Essays on Large-scale Integration into European Power Systems*. Université Paris Sud. https://tel.archives-ouvertes.fr/tel-01128060/document.

Henriot, A. and Glachant, J-M. 2015. Capacity Mechanisms in the European Market: Now, but How? In: Hancher, L., De Heuteclocque, A. and Sadowska, M. (Eds.) *Capacity Mechanisms in the EU Energy Market: Law, Policy, and Economics*, 1st ed. Oxford: Oxford University Press.

IEA. 2014. *World Energy Investment Outlook—Special Report*. Paris. https://www.iea.org/publications/freepublications/publication/WEIO2014.pdf.

IEA. 2016a. *Next Generation Wind and Solar Power—From Cost to Value*. International Energy Agency Books Online. https://www.iea.org/publications/freepublications/publication/Next_Generation_Windand_Solar_PowerFrom_Cost_to_ValueFull_Report.pdf.

IEA. 2016b. *World Energy Outlook*. Paris.
IEA. 2017a. *Energy Statistics*. https://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf.
IEA. 2017b. *Getting Wind and Sun onto the Grid: A Manual for Policy Makers*. International Energy Agency. https://www.iea.org/publications/insights/insight-publications/Getting_Wind_and_Sun.pdf?utm_content=buffer2f188&utm_medium=social&utm_source=twitter-ieabirol&utm_campaign=buffer&utm_content=buffer2f188&utm_medium=social&utm_source=twitter-ieabirol&utm_camp.
Jamasb, T. and Pollitt, M. 2008. Security of Supply and Regulation of Energy Networks. *Energy Policy* 36: 4584–4589.
de Jong, J., Maters, H., Scheepers, M. and Seebregts, A. 2006. *EU Standards for Energy Security of Supply*. https://www.ecn.nl/docs/library/report/2006/c06039.pdf.
Joskow, P.L. 2006. *Competitive Electricity Markets and Investment in New Generating Capacity*. http://economics.mit.edu/files/1190.
Keay, M., Rhys, J. and Robinson, D. 2013. Electricity Market Reform in Britain: Central Planning Versus Free Markets. In :Sioshansi, F.P. (Ed.) *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*. London: Academic Press, pp. 31–57.
Kondziella, H. and Bruckner, T. 2016. Flexibility Requirements of Renewable Energy Based Electricity Systems—A Review of Research Results and Methodologies. *Renewable and Sustainable Energy Reviews* 53: 10–22.
Lieb-Dóczy, E., Börner, A.R. and MacKerron, G. 2003. Who Secures the Security of Supply? European Perspectives on Security, Competition, and Liability. *Electricity Journal* 16: 10–19.
Mersinia, I. and Penttinen, S-L. 2017. Introduction. In: Mersinia, I. and Penttinen, S-L. (Eds.) *Energy Transitions: Regulatory and Policy Trends*. Intersentia (ELRF Collection).
Meyer, R., Gore, O., Brunekreeft, G. and Viljainen, S. 2014. *Analysis of Capacity Remunerative Mechanisms (CRMs) in Europe from the Internal Electricity Market Point of View*. Elforsk rapport 40114.
Newbery, D. 2013. Evolution of the British Electricity Market and the Role of Policy for the Low-Carbon Future. In: Sioshansi, F.P. (Ed.) *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*. Academic Press, pp. 3–29.
Nicolosi, M. and Fürsch, M. 2009. *The Impact of an Increasing Share of RES-E on the Conventional Power Market—The Example of Germany*. http://www.ewi.uni-koeln.de/fileadmin/user_upload/Publikationen/Zeitschriften/2009/09_03_01_Nicolosi_Fuersch_Zfe.pdf.
Ofgem (2010) *Action Needed to ensure Britain's Energy Supplies Remain Secure*. https://www.ofgem.gov.uk/ofgem-publications/76371/ofgem-discovery-phase-ii-draft-v15pdf.
Ragwitz, M. et al. 2011. *RE-Shaping: Shaping an Effective and Efficient European Renewable Energy Market*. https://www.reshaping-res-policy.eu/downloads/Final report RE-Shaping_Druck_D23.pdf.

Rodilla, P. and Batlle, C. 2012. Security of Electricity Supply at the Generation Level: Problem Analysis. *Energy Policy* 40: 177–185.

Rodilla, P. and Batlle, C. 2013. Security of Generation Supply in Electricity Markets. In: Perez-Arriaga, I. J. (Ed.), *Regulation of the Power Sector*. London: Springer.

Roques, F. 2014. *European Electricity Markets in Crisis: Diagnostic and Way Forward*. https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/archives/CGSP_Report_European_Electricity_System_030220141.pdf.

Rutherford, J.P., Scharpf, E.W. and Carrington, C.G. 2007. Linking Consumer Energy Efficiency with Security of Supply. *Energy Policy* 35: 3025–3035.

Şahin, T. 2017. Integration of European Capacity Remuneration Mechanisms: In Search of a Harmonized Regulatory Framework. In: Penttinen, S.L. and Mersinia, I. (Eds.), *Energy Transitions: Regulatory and Policy Trends*, vol. 5. Cambridge: Intersentia, pp. 11–33.

Şahin, T. 2018. *Capacity Remuneration Mechanisms in Energy-Only Markets in Pursuit of Creating A Regulatory Framework for the Integration of Capacity Remuneration Mechanisms in the European Union Electricity Markets*, PhD Thesis (Unpublished), University of Dundee.

Sauter, W. and Schepel, H. 2009. *State and Market in European Law: The Public and Private Spheres of the Internal Market before the EU Courts*. Cambridge: Cambridge University Press.

Sensfuß, F., Ragwitz, M. and Genoese, M. 2008. The Merit-order Effect: A Detailed Analysis of the Price Effect of Renewable Electricity Generation on Spot Market Prices in Germany. *Energy Policy* 36: 3086–3094.

Smil, V. 2010. *Energy Transitions: History, Requirements, Prospects*. California: Praeger.

Tennbakk, B., Capros, P., Delkis, C., Tasios, N., Zabara, M., Noreng, C.H. and Skånlund, A.B. 2013. Capacity Mechanisms in Individual Markets Within the IEM. *Supra note* 174: 30–35.

Vanderberghe, W. and Gonne, R. 2015. Belgium. In: Hancher, L., De Hauteclocque, A. and Sadowska, M. (Eds.) *Capacity Mechanisms in the EU Energy Market: Law, Policy, and Economics* 1st ed.. Oxford: Oxford University Press, pp. 241–255.

De Vries, L. J. 2007. Generation Adequacy: Helping the Market Do Its Job. *Utilities Policy* 15: 20–35.

de Vries, L. J. and Hakvoort, R. A. 2004. *The Question of Generation Adequacy in Liberalised Electricity Markets*. https://doi.org/10.2139/ssrn.600503.

Waldron, M. and Nobuoka, Y. 2017. *Commentary: Commentary: Changing Utility Business Models and Electricity Investment*. https://www.iea.org/newsroom/news/2017/december/commentary-changing-utility-business-models-and-electricity-investment.html.

Wright, P. 2005. Liberalisation and the Security of Gas Supply in the UK. *Energy Policy* 33: 2272–2290.

Part II

Managing the Decline of Fossil Fuels

5

China's Efforts to Constrain its Fossil Fuel Consumption

Philip Andrews-Speed

1 Introduction

China is the world's largest consumer of commercial energy, accounting for 23% of the global total in 2017. Some 86% of this consumption is in the form of fossil fuels, down from 95% in 1990. However, the total consumption of energy has risen more than fourfold over this period, leading to a fourfold increase of fossil fuel combustion (Fig. 5.1). As energy consumption has risen, so have carbon dioxide (CO_2) emissions (Fig. 5.2). This rapid growth of energy demand was driven by a booming economy with a strong heavy industry. The size and mix of its energy consumption makes China the largest emitter of CO_2, accounting for an estimated 27% of the world's CO_2 emissions from energy (BP, 2018). At the same time, air pollution has worsened to such an extent that its mitigation has become a high political priority for the government.

In response, the government has promulgated a series of policies, notably since 2003, intended to constrain coal consumption, promote the use of non-fossil fuels, and enhance energy efficiency. As a result, China now has the world's largest installed capacity of hydro-electricity, wind and solar energy, as well as the fastest growing fleet of nuclear energy plants. The government has combined massive investment in clean energy infrastructure with measures to constrain the production and consumption of coal and to drive down energy intensity. The simultaneous slowing and rebalancing of the national economy

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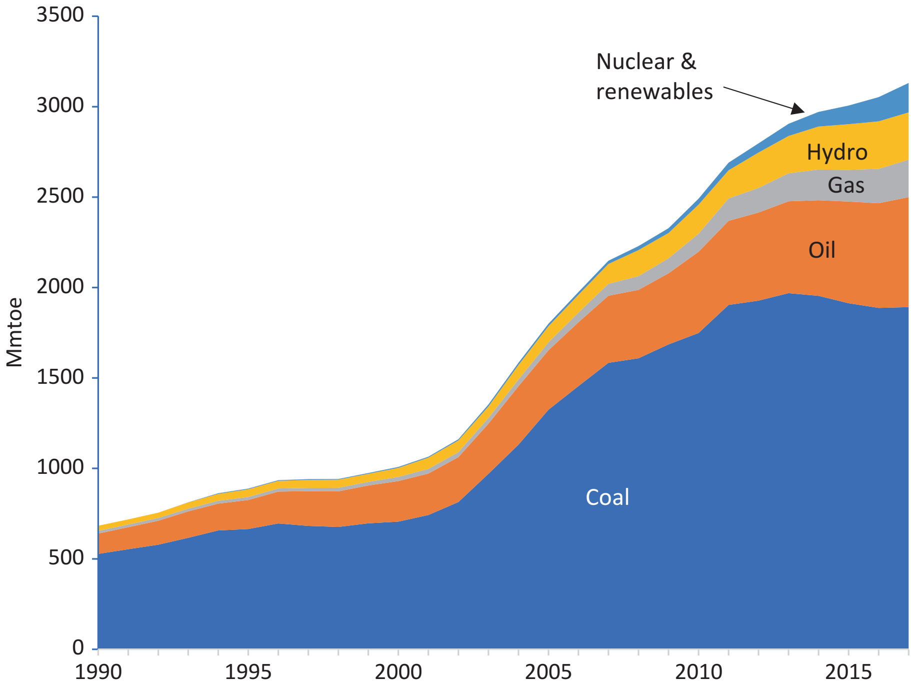

Fig. 5.1 China's primary energy consumption mix (1990–2017). (Source: Data adapted from BP, 2018)

led to coal consumption and carbon emissions from energy to peak over the years 2013 and 2014, though they picked up marginally in 2017. Furthermore, Chinese manufacturers have taken the world by storm to become the largest suppliers of renewable energy equipment, notably solar photovoltaics (PV), as well as the dominant constructors of hydroelectric dams. Despite these achievements, the switch away from fossil fuels is likely to remain slow but steady for as long as the economy continues to grow at current annual rates of about 6%.

The aims of this chapter are to examine a selection of these policy programmes in order to identify the sources of success, as well as the limitations and unintended consequences, and to provide a prognosis for the future. China's strategy for shifting away from and improving the use of fossil fuels has a number of different components. The most relevant to this chapter are: Improving the efficiency of coal-fired power stations and industrial plants; Switching from coal to gas; Testing carbon capture and storage or use; and Boosting the share of low-carbon energy sources in the power sector.

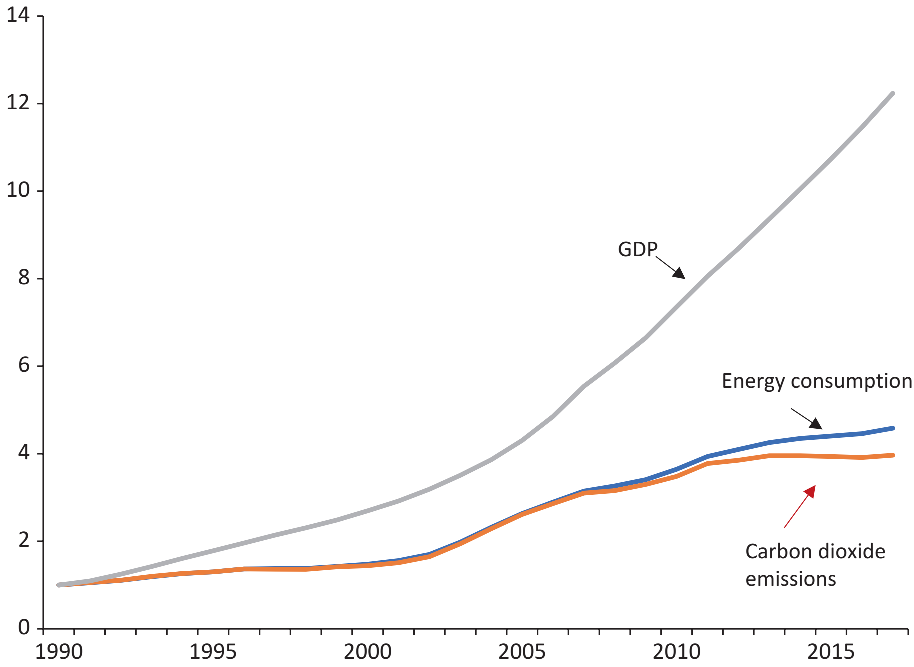

Fig. 5.2 China's GDP, Primary energy consumption and carbon dioxide emissions from energy (1990–2017, normalised to 1990). (Sources: BP, 2018; National Bureau of Statistics, 2017, 2018)

The transport sector accounts for about 10% of China's primary energy consumption and is another significant user of fossil fuels. Oil consumption for transport increased threefold between 2000 and 2015 (International Energy Agency (IEA), 2017). Although China is pushing ahead relatively rapidly with the development of electric vehicles, fossil fuels will provide much of the electricity required. Natural gas and biofuels are also starting to make inroads into the fuel mix for transport. Due to the complexity of these trends, the transport sector lies beyond the scope of this chapter.

The first two sections of this chapter set the scene by first describing the wider context of governance in China and then explaining the energy policy challenges facing the government and the responses. The succeeding sections analyse in more detail the progress of policies to reduce the role of fossil fuels, especially of coal, looking in turn at reducing coal use, boosting gas consumption, testing carbon capture, and promoting low-carbon electricity.

The chapter concludes that the further reduction of fossil fuel consumption will be a gradual process relying on sustained government support for alternative forms of energy and pressure to reduce the use fossil fuels. Many forces are aligned against these trends, not least the coal and power companies and local governments, as well as energy consumers that value the low cost of coal. It is not evident that the planned national emissions trading scheme will address these obstacles effectively, given the continuing state ownership of most major energy producing and consuming enterprises.

2 The Governance Context

China is a Leninist state led by a strong Communist Party. Since 1949 the party-state has built substantial capacity to govern the country and, using the terminology of Douglass North et al. (2009), may be regarded as a mature, limited access social order (Andrews-Speed, 2012). Despite its primacy, the Party, acting through the government, has never really possessed a monopoly on power. Its capacity for formulating and implementing policy remains highly constrained by the structures of government, the distribution of power within and outside government, and the processes that govern policy-making. Since 1978, the central government has progressively delegated substantial policy-making powers to the provinces and lower levels of government, particularly to the counties that have gained considerable influence over policy implementation (Lieberthal, 1995; Zheng, 2010).

The difficulties faced by the central government in formulating and implementing policy are captured by terms such as 'fragmented authoritarianism' (Lieberthal and Oksenberg, 1988) and "polymorphous state" (Howell, 2006). These expressions reflect the multiplicity of vertical and horizontal lines of authority within government, combined with the poorly defined and overlapping responsibilities of individual agencies, and the influence of state-owned enterprises. This structural complexity is exacerbated by the preference for decision-making through consensus, poor coordination between government departments, and a tendency for agencies to avoid making difficult decisions by passing the problem up the hierarchical tree. These features characterise what can be termed the 'institutional environment' (Williamson, 2000), namely the political and economic systems, the bureaucratic structures and systems of government, and the formal allocation of powers between different levels of government. Also, of great significance are the features of the law relating to property rights, contract and dispute resolution, the systems for policy-making and implementation, and the role of civil society and the media (Andrews-Speed, 2012, 2016).

China's economy has undergone an almost complete transformation since Deng Xiaoping began his strategy of progressive liberalisation in 1978. Before that time, the central government planned all production and consumption. Despite the widespread demise of state ownership of industrial enterprises, the government has kept control over a small number of sectors that it perceives as having strategic economic importance (Li, 2015). These include banking, energy, telecommunications, mining, metallurgy, chemicals and railways.

The major economic challenge facing Xi Jinping's government in 2013 arose from the economic stimulus package launched in 2009 by the previous administration to address the impact of the global financial crisis. The four trillion Yuan stimulus led to massive overinvestment in industrial capacity and subsequent oversupply in a wide range of commodities and goods. Just as significant, the surge in heavy industry output exacerbated the already bad air pollution and enhanced the level of carbon emissions. As a result, the administration that took over in 2013 faced the twin challenges of economic adjustment and pollution abatement (Dittmer, 2017). Economic adjustment involved allowing the economy to slow down by constraining the use of stimulus measures and rebalancing the economy away from heavy industry toward services through the enforced closure of excess and inefficient industrial capacity. The aim of this process is to achieve the new normal. In turn, the closure of old, polluting plants, along with other measures, is intended to reduce air pollution. In line with this move to a 'new normal', further economic priorities for the government have been to enhance the role of market forces in the allocation of goods and resources, to increase the role of non-state finance in industry, and to selectively merge state-owned enterprises.

The governance of the energy sector today has its origins in the Marxist-Leninist system put in place by Mao after 1949. At that time, the state took full control of the sector through the planning of production and consumption, ownership of the main energy producing and consuming enterprises, and control over producer and consumer prices (Andrews-Speed, 2004; Kambara and Howe, 2007). The processes of enterprise privatisation and market liberalisation in the energy sector have been slow and hesitant, with decisive steps being taken only in the period 1997–2003 (Andrews-Speed, 2012) and more recently under Xi Jinping.

The key government agency overseeing the energy sector is the National Development and Reform Commission (NDRC), in part through its subordinate National Energy Administration (NEA). It retains oversight of investment in the energy sector, though considerable authority has been delegated to the provinces, continues to set some energy prices, and retains the role of formulating and overseeing the implementation of key energy policy initiatives.

Several other agencies have also been involved in the governance of the energy sector, notably the Ministries of Finance, of Industry and Information Technology, of Commerce, of Land and Resources, of Water Resources, and of the Environment, and the State-owned Assets Supervision and Administration Commission (SASAC) (Fig. 5.3). A National Energy Commission was created in 2010 but is deemed to have been largely ineffective (Grunberg, 2017). Some level of coordination is provided by the Leading Group on Climate Change, Energy Saving and Emission Reduction that is chaired by Premier Li Keqiang. Despite these moves and the growing role of the Communist Party's Leading Small Groups, the governance of energy remains fragmented (Grunberg, 2017). At the same time, there is little separation of policy-making, design, planning and implementation (Davidson et al., 2017). The NDRC, the NEA, and these various agencies all have equivalent bureaus at provincial and lower levels of government that are charged with adopting, adapting and implementing central government policies.

The government reforms announced in March 2018 (Fig. 5.4) appear to have slightly reduced the central role of the NDRC and NEA in the governance of the energy sector. The creation of a new Ministry of Ecology and Environment is particularly significant as it centralises functional responsibility

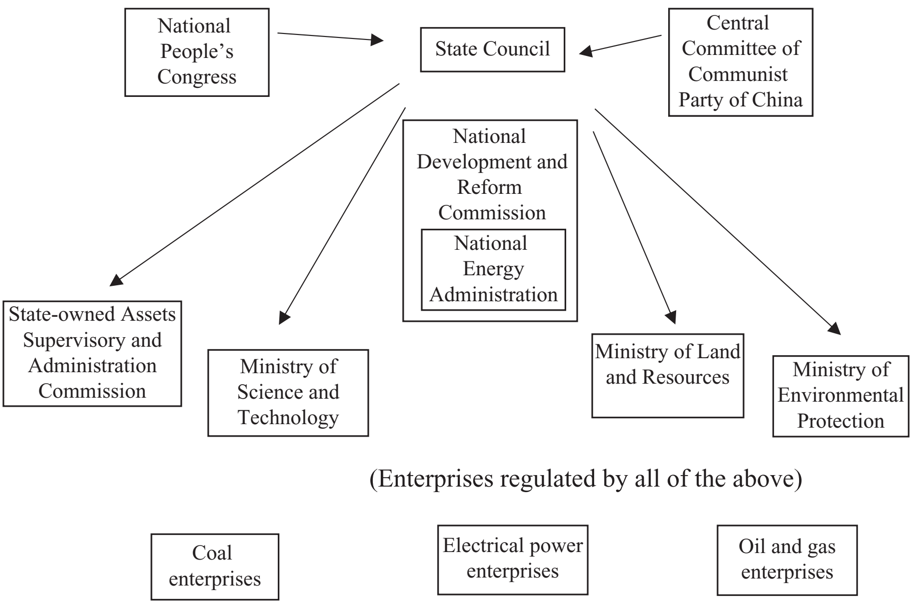

Fig. 5.3 Simplified scheme showing the main energy-related organisations and enterprises at central government level between 2013 and 2018. All organisations had local bureaus or subsidiaries at provincial, prefecture and county levels

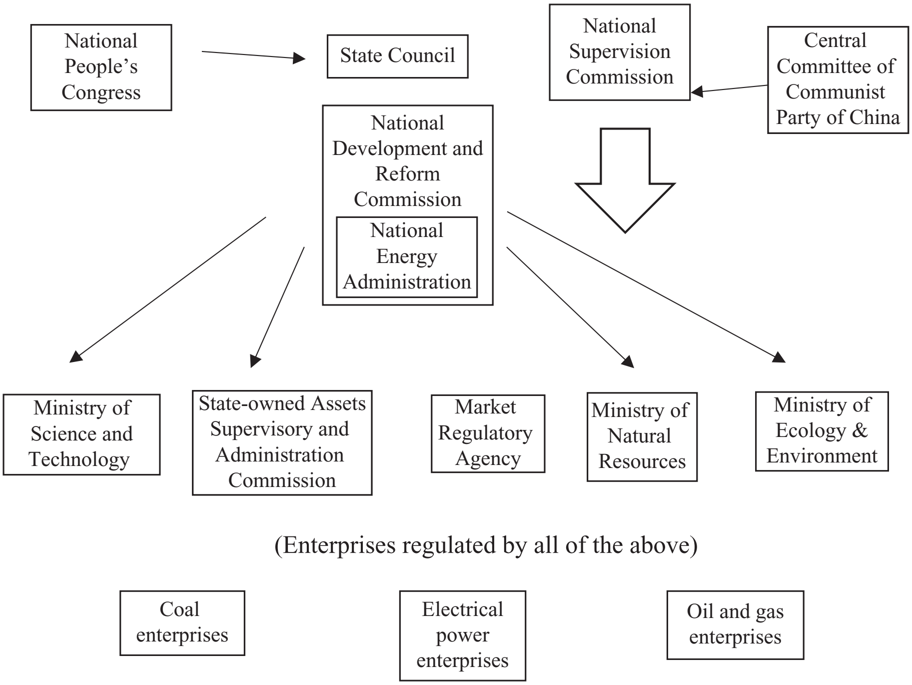

Fig. 5.4 Simplified scheme showing the main energy-related organisations and enterprises at central government level after March 2018. All organisations had local bureaus or subsidiaries at provincial, prefecture and county levels

for a variety of environmental issues, including climate change, that were previously scattered across different agencies.

The state-owned enterprises in the coal, electricity and oil and gas industries are key policy actors. Each of these industries originated as central government ministries with bureaus at the various lower levels of government. Gradual structural reforms initiated in the 1980s led to progressive process of corporatisation, structural unbundling or adjustment, forced mergers, commercialisation, and partial privatisation that continues today. Despite partial privatisation through initial public offerings, these enterprises retain close links with government and the Party at either central or local government levels (Andrews-Speed, 2012). In the past, the Chairmen and CEOs of the largest energy State-Owned Enterprises (SOEs) could aspire to senior government or party positions (Leutert, 2018).

3 The Main Energy Policy Challenges and Responses

The ranking of energy policy priorities has changed over the past thirty years and recently the environment has become as important as security of supply. The steady evolution of policy has been punctuated by more dramatic shifts triggered by domestic or international events.

The 1990s was a period of rapid economic reform and opening up to foreign investment. Gross domestic product (GDP) was rising at around 10% per year (see Fig. 5.2), though it declined during the Asian financial crisis of 1997–1998. During the 1990s, the top priority for energy policy was to supply sufficient energy, preferably from domestic sources, to support economic growth. Renewable energy was not a high priority, with the exception of large-scale hydro-electricity that continued to supply 20% of the nation's electricity supply.

Following China's participation in the UN Conference on Environment and Development in Rio de Janeiro in 1992, the government formally recognised that sustainable development should form an important part of the national policy agenda (Geall and Ely, 2015). Thus, the 1990s became the first time that the quality of economic growth and energy supply became a priority for government, rather than the sheer quantity. This resulted in the publication of the *National Agenda 21* in 1994 and the first *National Sustainable Development Report* in 1997.

Security of energy supply rose to the top of the government's agenda in 2004. The government had launched an economic stimulus package in 2002 that saw GDP growth rates rise above 10%, with a strong contribution from the energy-intensive heavy industries. Energy demand surged (see Fig. 5.1) and both energy intensity and carbon intensity started to rise after a period of decline (Fig. 5.5). A significant proportion of these carbon emissions were related to exports (Grubb et al., 2015). Energy supply could not keep up with rising demand and shortages of electricity and oil products started to appear across the country in 2003.

This was the situation that faced the new government of President Hu Jintao and Premier Wen Jiabao that took office in 2003. The response was decisive and vigorous. The *Medium and Long-Term Energy Conservation Plan* issued in 2004 set the goal of reducing national energy intensity by 20% between 2005 and 2010, and to continue this rate of decline until 2020. The *Eleventh Five-Year Plan for Energy Development 2006–2010* reinforced these priorities. Specific targets were set for individual energy-intensive industries

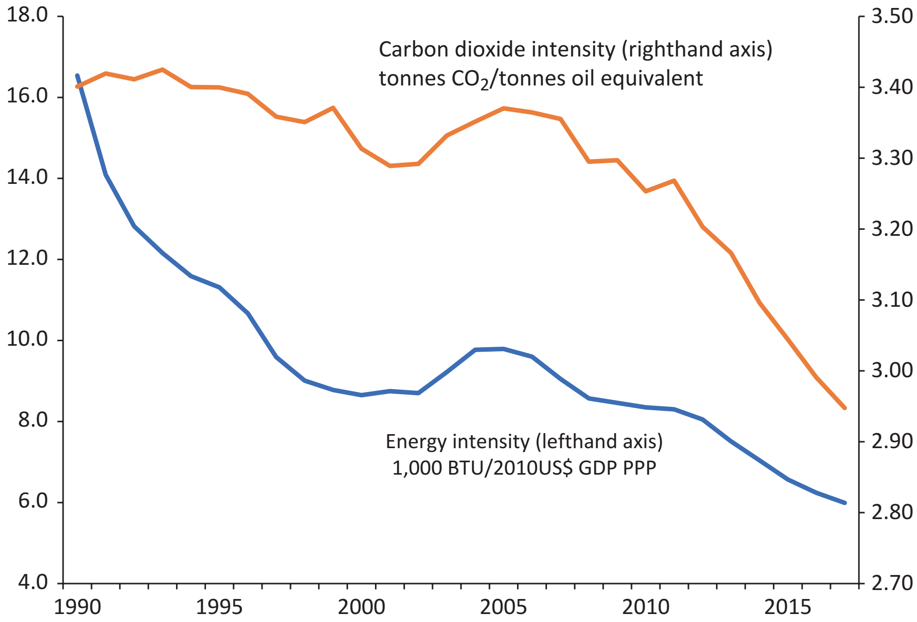

Fig. 5.5 China's energy intensity per unit GDP and carbon intensity of energy use, 1990–2017. (Sources: Raw data obtained from the following: energy intensity (US Energy Information Administration, 2018), updated from online press announcements for 2016 and 2017; carbon intensity calculated from BP, 2018)

and provincial governments, and electricity tariffs rose for industrial and commercial enterprises. The central government supported these and other related measures with trillions of RMB of financial support. These efforts succeeded in constraining the rate growth of energy consumption and carbon dioxide emissions (see Fig. 5.2). They led to the reduction of national energy intensity by 19.1%, not far below the target of 20% and an impressive achievement. The degree of decoupling between GDP growth and both energy consumption and CO_2 emissions jumped significantly (see Fig. 5.2).

From 2005 onwards, the environment became an increasingly important topic of public debate and of official pronouncements as both global climate change and domestic environmental degradation were being seen as threats to national security and societal wellbeing (Nyman and Zeng, 2006). For the first time, renewable energy became an integral part of energy policy, as marked by the promulgation of the *Renewable Energy Law* in 2005. This was followed by the *Climate Change Law* in 2007, soon after China was identified as the world's largest emitter of greenhouse gases. Two years later, at the United Nations Climate Change Conference in Copenhagen, China announced that it would reduce its carbon emissions intensity by 40–45% between 2005 and 2020. These interventions led to an acceleration of the share of non-fossil fuels in primary energy supply (see Fig. 5.1) and electricity supply (Fig. 5.6).

Whilst climate change had reached the forefront of international discourse relatively recently, air pollution had long been an issue of concern within China. The government started to take steps to address air pollution from coal combustion back in the 1980s and these measures steadily intensified over the succeeding two decades. By 2005, policies included raising the levy for sulphur dioxide (SO_2) discharge, closing small and inefficient thermal plants, supporting the construction of highly efficient coal-fired plants, enforcing the installation and use of flue-gas desulphurisation (FGD) equipment, and constraining the mining of high-sulphur coal (Finamore and Szymanski, 2002). This led to a steady decline in SO_2 and related emissions. However, the economic stimulus that followed the global financial crisis brought a halt to these improvements. In the winter of 2011/2012, the public outcry at the worsening air pollution in some of China's major cities appeared to threaten the legitimacy of the Communist Party. The government responded in 2013 with

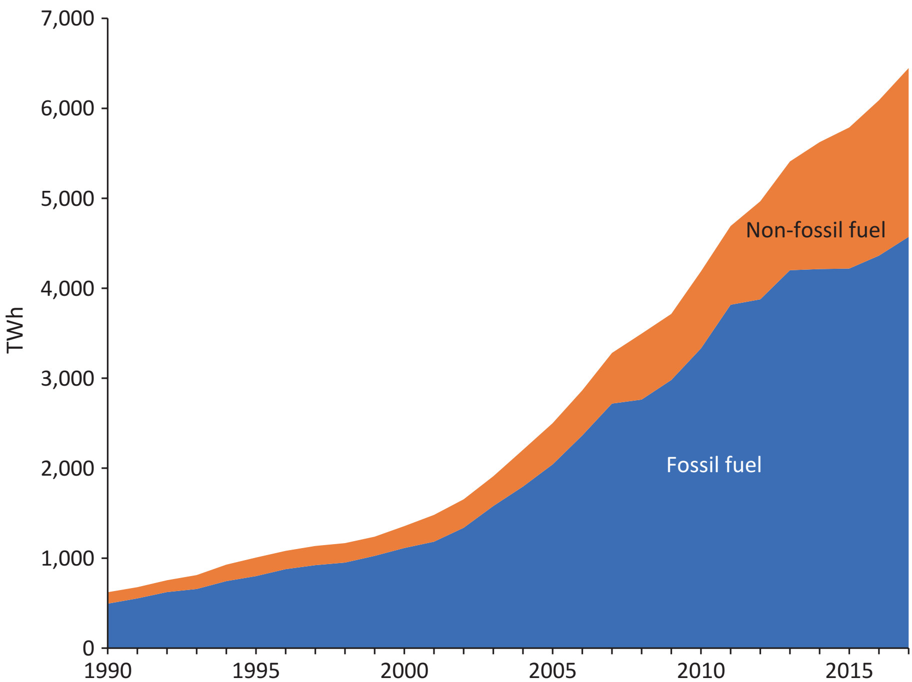

Fig. 5.6 China's electricity supply mix—fossil and non-fossil fuels (1990–2017). (Source: Data adapted from BP, 2018)

a *National Action Plan on Air Pollution Control*. This set a number of quantitative targets to be achieved by 2017 and a range of measures to help achieve these goals. These included constraining coal consumption, enhancing the use of natural gas, and continuing to boost the share of non-fossil fuels in the energy mix. In 2018, the battle to reduce air pollution remains high on the government's agenda, even at the cost of soaring liquefied natural gas imports needed to replace coal in northern China.

3.1 Improving Coal Use

In 2017, coal provided about 60.5% of China's primary energy consumption (BP, 2018). This was a significant decline from around 75% in the early and mid-1990s. Although annual coal demand has fallen from a peak of 3,970 million tonnes in 2013 to 3,815 million tonnes in 2017, the nation still accounts for 50% of world's consumption (BP, 2018). About half of this coal is used for power generation and most of the balance is consumed by industry (IEA, 2017). Despite the growing importance of low-carbon electricity, coal still accounts for 67% of the country's electricity generation, down from 75% in the 1990s (BP, 2018). Coal continues the dominant feedstock due to the country's vast natural endowment, though natural gas is starting to play a minor role today. In the same way, coal has been the fuel of choice for many industries, especially the energy intensive ones such as steel, non-ferrous metallurgy, cement, and plate glass. Coal is also a feedstock for some chemical processes such as the manufacture of synthetic nitrogenous fertilizer.

The energy supply crisis of the early 2000s triggered a succession of measures to curb energy consumption across the economy, with a particular emphasis on heavy industry and the power sector. Measures specific to coal-fired power generation were wide ranging and had the aim of reducing average coal consumption in thermal power plants from 392 gce/kWh in 2000 to 320 gce/kWh in 2020 as well as reducing air pollution (Mao, 2009; Ma and Zhao, 2015; Yuan et al., 2016a):

- Banning the constructing of plants with a capacity of less than 135 MW;
- Decommissioning plants below 100 MW capacity and replacing small-scale plants with large-scale ones;
- Prioritising the construction of plants of 600 GW capacity or larger, and the deployment of supercritical and ultra-super critical technologies;
- Upgrading older plants that had not been closed; and
- Building more combined heat and power (CHP) capacity.

In support, the *12th Five-Year Plan for Energy Science and Technology Development 2011–2015* and the *13th Five-Year Plan for Energy Technology Innovation 2015–2020* both identified supercritical and ultra-super critical technologies as key priorities, along with integrated gasification combined cycle (IGCC) technology. The policy instruments deployed were mainly administrative in nature, for example through the centralised approval process for investment and through energy efficiency benchmarking (Na et al., 2015). Financial support was provided through compensation for plant closures and loans for new capacity that met the technological requirements (Yuan et al., 2016a).

These measures met with a high degree of success. By the end of 2015 more than 100 GW of small-scale plants had been closed. In 2016, the National Energy Administration (NEA) issued a further list of some 70 GW of plants to be decommissioned by 2020, and later raised this target to 109 GW. In 2017 alone, 65 GW of coal-fired capacity was decommissioned or suspended. By 2015, China's fleet included 219 GW of supercritical and 155 GW of ultra-supercritical plants, and average net coal consumption for thermal power plants had declined to 315 gce/kWh (Myllyvyrta and Shen, 2016; Yuan et al., 2016a; Yeager, 2016). A growing proportion of the coal-fired plants were being built in the north and west of the country, near the coal mines, to support economic development in these regions, to reduce the amount of energy used transporting coal, and to constrain air pollution in the south and east (Myllyvyrta and Shen, 2016).

However, this success was partly undermined by a separate policy decision in 2013 to relax the need for central government approval for many types of new infrastructure project, including thermal power plants. This led to a surge of construction approved by provincial governments that brought 170 GW of coal-fired capacity online between 2012 and 2015, just as annual demand growth was slowing from 12% in 2011 to 0.5% in 2015 (Yuan et al., 2016b). As a result, the average load factor of thermal plants declined from 62% in 2011 to less than 45% in 2015. By this time, a further 200 GW of coal-fired capacity was under construction and permits had been issued for an additional 55 GW. In response, the central government took back the approval process and instructed provincial governments to delay projects that had not broken ground and to stop approving new projects unless there was a clear need (Myllyvyrta and Shen, 2016). These measures succeeded in reducing the number of coal-fired plants commissioned to 47 GW in 2016 and 34 GW in 2017. However, by the end of 2017, the installed capacity of the coal-fired fleet had reached about 1,100 GW out of a total of 1,670 GW, and 95 GW of new coal-fired capacity was still under construction (Shearer et al., 2018).

A side effect of the push for more efficient thermal power stations has been that construction of massive new capacity over the past few years may lock the country into coal-fired power for decades (Zhang and Qin, 2016). Alternatively, if the coal-fired plants become redundant, the power companies and the state will suffer from substantial stranded costs (Caldecott et al., 2017). Finally, coal remains the swing fuel in China's economy. When economic growth or industrial activity picks up, coal consumption rises, as occurred in 2017.

3.2 Boosting the Share of Natural Gas

Natural gas has a potentially important role to play in China's clean energy strategy. In replacing coal, it would reduce both air pollution and carbon emissions. Until the mid-1990s natural gas played little part in China's national energy policy. The discovery of large accumulations of tight gas in the Ordos Basin of northern China occurred at a time when the country was starting to become an importer of oil and energy security was rising on to the central government's agenda. Further discoveries in northwest China allowed annual production to grow from 18.5 billion cubic metres (bcm) in 1995 to 51.0 bcm in 2005 (Fig. 5.7).

The growing need to reduce air pollution provided a further incentive to increase domestic natural gas production in order to substitute gas for coal. A sustained programme of exploration boosted China's estimated recoverable reserves of natural gas from 1.4 trillion cubic metres (tcm) in 2000 to 5.5 tcm in 2017 and production reached 149 bcm by 2017 (BP, 2018). Delivery of this gas to the energy consuming regions of eastern China has required the rapid construction of a completely new network of domestic gas pipelines. The most impressive of these are the three West–East pipelines that bring natural gas from the Tarim Basin of Xinjiang and from Central Asia to the eastern regions of China.

In order to boost the domestic production of gas, the government has supported the development of three types of unconventional gas: coal-bed methane, shale gas and synthetic natural gas. However, none of these forms of gas have yet to provide a significant contribution to China's total gas supply. The year 2017 saw annual production of 7.0 bcm for coalbed methane, 9.0 bcm for shale gas, and 2.2 bcm for synthetic natural gas (Askci Consulting, 2018; Liu, C., 2018). This amounted to just 12% of total national gas production. The pace of development of both coalbed methane and shale gas has lagged behind the government's projections because of technical and commercial

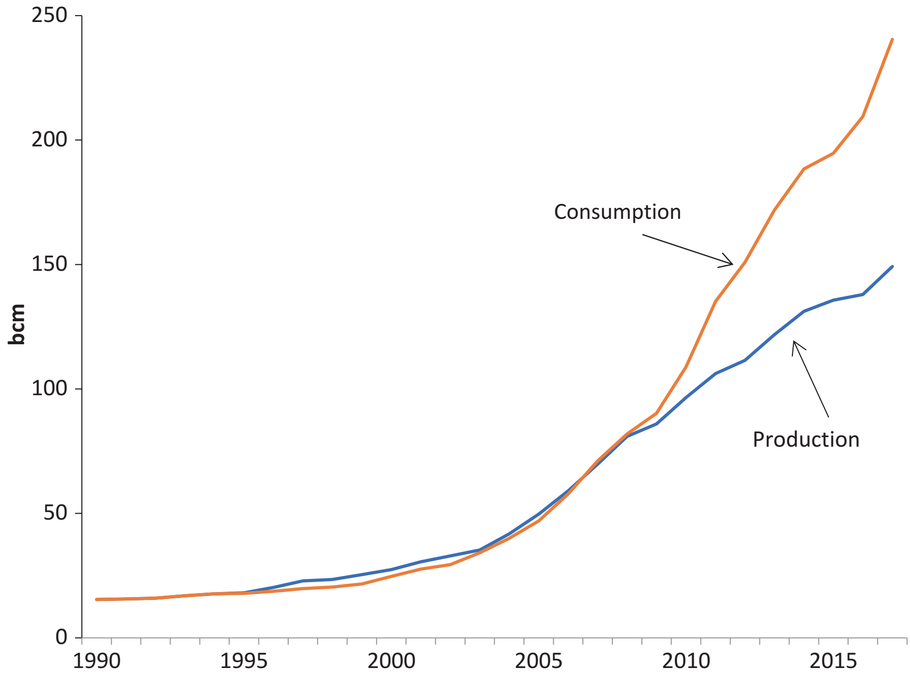

Fig. 5.7 Production and consumption of natural gas in China (1990–2017). (Source: BP, 2018)

challenges, whilst the production of synthetic natural gas poses significant environmental risks.

Annual consumption of natural gas has risen more than tenfold since 1999 to 240 bcm in 2017, with a surge of 30 bcm in 2017 alone (see Fig. 5.7). In order to fill the gap between domestic supply and demand, China has had to import gas supplies through pipelines and on ships as liquefied natural gas (LNG). Total imports of natural gas have risen from 1 bcm in 2006 to 92 bcm in 2017 (BP, 2018). Pipelines are seen by China's government as being more secure than LNG, because the flow of gas is not open to interruption on the high seas. Central Asia and Russia both contain substantial proven and potential reserves of gas that can be imported through pipelines and make a major contribution to China's gas supply. In 2017, Central Asia, mainly Turkmenistan, provided 35 bcm or 90% of the country's pipeline imports of gas (BP, 2018). In Russia, progress in developing and exporting gas resources to China has been slow, despite initial planning and discussions that date back to the late 1990s. Construction of an export pipeline to China began after final agreement was reached in 2011 and is due to be completed at the end of 2019. A gas pipeline from Myanmar was commissioned in 2013, and the annual quantity of gas should reach 10 bcm by 2020.

LNG is more cost-effective than pipeline over very long distances. It is also more flexible, because a buyer of gas can have several suppliers, and more adaptable to sudden surges of demand, as was seen in 2017. Since 2013, LNG has consistently accounted for 45–50% of China's imports of natural gas. Australia provides almost half of this supply, with Qatar, Malaysia, Indonesia and Papua New Guinea accounting for most of the balance. Imports of LNG soared from 34 bcm in 2016 to 52.6 bcm in 2017 (BP, 2018), because of a push to switch from coal to gas in northern China. By the end of 2017, 15 LNG receiving terminals were operational with an annual capacity of 76 bcm. Current plans would add more than ten terminals by 2020 bringing receiving capacity to about 110–120 bcm.

Despite this rapid rise in consumption, natural gas only contributed 6.6% of primary energy consumption in 2017 due to the sustained growth of total energy demand, and only 3.0% of electricity generation (BP, 2018). Urban residential and commercial sectors dominate the end-use of natural gas, accounting for 37.6% of the total. The shares taken by industry, power generation and as feedstock for the chemical industry had reached 30.9%, 19.9% and 11.6% of national gas consumption respectively by 2017 (Sun, 2017).

The underlying constraint to enhancing the use of natural gas in China lies in a combination of geology and cost. Little of China's domestic gas resources are cheap to deliver to the end-user, because of either difficult geology or remote location. The growing role of shale gas and coalbed methane will only add to these costs, as discussed above. The price of imported gas depends on the contractual terms and can fluctuate with market conditions. Nevertheless, little if any of this domestic or imported gas can compete with coal based on the cost, in the absence of a price on carbon (Qin et al., 2018).

A further obstacle lies in the dominance of the National Oil Companies (NOCs), especially PetroChina, in the upstream and midstream of the gas supply chain (Dong et al., 2017). On account of the geographic distribution of the gas reserves, PetroChina accounts for about 75% of domestic gas production and 80% of the onshore trunk pipelines (Shi and Varium, 2015). A key problem is third-party access to pipelines. The government issued some general guidelines on third-party access in 2014, but these produced little change. In August 2018, the NDRC issued for public consultation a new set of draft measures to promote third-party access to oil and gas pipelines (National Development and Reform Commission, 2018). These contained more detail on implementation that the previous guidelines. Assuming that these measures are adopted, much will depend on the availability of spare capacity in the pipelines and the rigour with which the measures are enforced. A parallel approach has been to encourage the NOCs to unbundle their pipeline operations and sell sections off to private investors, but this has been happening only slowly. A possible alternative is to gather all the oil and gas pipelines into a single state-owned enterprise separate from the NOCs (Bloomberg, 2018). This would represent true unbundling and greatly ease the third-party access problem.

The challenge of promoting natural gas use was well illustrated in months leading up to the winter of 2017/2018. Despite sustained efforts by central and local governments, air pollution levels rose in the first seven months of 2017 in comparison to the same period the previous year. As pollution hit record highs in the winter of 2016/2017, local governments suspended industrial production, closed schools and reduced road traffic. The government responded by launching a short-term campaign to accelerate the conversion of industrial plants and household appliances from coal to natural gas in northern China. The objective was to convert the heating systems of up to four million households to natural gas or electricity in 2017. At the same time, some 44,000 coal-fired boilers were to be scrapped and the sale of coal in the selected towns and villages banned. The construction of the necessary pipelines and storage tanks to support this dash for gas was an immense task with a cost of billions of RMB and could not be completed in the required time (Sandalow et al., 2018).

Although meeting with considerable success, the impetuous nature of this short-term gasification plan produced three undesirable consequences. First, although natural gas is more convenient and cleaner for families, it is more expensive than coal. Northern China is home to large numbers of low-income families and the high price of natural gas led many households to reduce their use of heating. To alleviate such hardship, the government provided a certain quantity of gas at subsidised prices. Second, many coal-fired heating systems that were decommissioned had not been replaced by gas-fired ones by the onset of winter, leaving households without any heating at all. Finally, the additional call on international markets for gas supplies had immediate effect on international markets, with Asian spot LNG prices reaching close to US$ 11 per million British Thermal Units (mmBTU) in January 2018, up from a low of less than US$6 per mmBTU in June 2017.

3.3 Carbon Capture and Storage or Use

Carbon capture and storage or utilisation (CCS/U) has long been seen as a significant component of global strategy for the low-carbon transition, though the timing and scale of widespread deployment has failed to meet earlier optimistic projections. Nevertheless, with its large scale of coal consumption, China should be one of the countries to take the lead in deployment of CCS/U. Recognising this, the Ministry of Science and Technology included this technology on its *Medium and Long-Term Plan for Science and Technology for 2006–2020*.

Huaneng Power International commissioned China's first industrial-scale carbon capture plant in 2008 (Huang et al., 2010). By the end of 2017, two-large scale CCS/U projects were under construction and due to be commissioned in 2019 and 2020. Both projects are linked to chemical plants, one for fertilizer the other for coal-to-liquids. The CO_2 will be piped to nearby oil fields for enhanced oil recovery (EOR). A further six projects were under development, including six power plants. At least three of these will support EOR, whilst the CO_2 from another will be sent for deep geological storage offshore (Liu, H., 2018).

The two key challenges to commercialising CCS/U in China, as elsewhere, are the cost of capture and the size and proximity of storage or utilisation options (International Energy Agency, 2016). The cost will depend on a range of variables including the power plant combustion technology, the quality of the coal and the plant capacity factor. For post-combustion, amine-based capture, the cost has been estimated to be around US$ 40/tonne of CO_2, though other techniques may be cheaper (Senior et al., 2011; Hu and Zhai, 2017). The retrofitting of existing power plants could be substantial. As a result, the government will need to put in strong incentives for the widespread deployment of CCS/U, even if the industry brings down the costs (Viebahn et al., 2015; International Energy Agency, 2016).

The challenge of storage has three components: geological suitability, potential for revenue generation, and distance (Viebahn et al., 2015). China hosts a number of petroleum basins that contain oilfields that would benefit from a supply of CO_2 for EOR purposes. This will provide revenue for the carbon capture project and is why most of the early commercial projects are being aimed at such use. The alternative is storage in saline aquifers. An initial study suggested that a large proportion of China's coal-fired plants appear to be too far (more than 250 km) from suitable storage sites. However, considerably more work needs to be carried out to assess the country's storage capacity (International Energy Agency, 2016).

4 Promoting Low-Carbon Electricity

Four forms of low-carbon electricity are together providing an increasing share of China's electricity supply (see Fig. 5.6). Large-scale hydroelectricity has long been a stable part of the fuel mix, and nuclear power is set to provide a significant share of the base load. The installed capacity of intermittent wind and solar energy has grown rapidly in recent years, though faces serious curtailment challenges.

4.1 Hydroelectricity and Nuclear Power

Hydroelectricity and nuclear energy may be considered relatively clean forms of electricity in respect of carbon emissions and air pollution, notwithstanding other consequences and risks associated with these sources of electricity. Both can be constructed at a large scale and are able to form the backbone of a nation's electricity supply. As a result, the second half of the twentieth century saw China, like many other countries, construct substantial capacity for hydroelectricity and, more recently, embark on the development of nuclear energy to support economic development. The gradual emergence of a clean energy agenda in the early years of this century added a new source of support for these forms of energy. As a result, hydroelectric power has consistent provided 15–20% of China's electricity supply, despite soaring demand growth, and nuclear power now provides almost 4% (BP, 2018).

The systematic construction of hydroelectric dams date back to the early years of Communist rule in the 1950s, when large-scale project were built to supply electricity for industry and, later, small-scale dams were constructed for the rural population (Xu, 2002). The 1980s saw a shift back to the construction of large-scale dams to support the industrialization and economic development envisaged by Mao's successors. As a result, total hydroelectric generating capacity grew from 20 GW in 1980 to 86 GW in 2002. It was during this period, that approval was eventually given for the construction of the 22.5 GW Three Gorges Dam on the Yangtze River (Yeh and Lewis, 2004). The recent recognition of the need to address global climate change by increasing the use of non-fossil energy sources will see hydro capacity rising to at least 350 GW by 2020. From then on, construction is likely to slow down as the capacity reaches its technically and economically feasible limits, which will probably lie between 400 and 500 GW (Vermeer, 2012; Matthews and Tan, 2015).

Despite this success in terms of creating power generation capacity, China's large-scale dams have created a high level of controversy on account of the need to displace large populations and the environmental damage, as well as possible seismic risks (Jing, 1997; Shapiro, 2001). The most notorious is the Three Gorges Dam on the Yangtze River that was completed in 2006. The opposition to the project was so great, both inside and outside China that the World Bank refused to provide financial support. The creation of the reservoir has caused more than 1.2 million people to be resettled, a process that was plagued by delays and corruption. In addition, the pollution of the reservoir water has been much greater than expected (Economy, 2004). Plans to build dams along the Nu (Salween) River in southwest China has also attracted opposition from domestic and international NGOs and individual Chinese activists.

The possibility of developing nuclear power was mentioned in the *First Five-Year Plan* of 1953, but then was dropped as attention switched to developing an atomic bomb (Sovacool and Valentine, 2012). Only in 1978 did the government formally announce that China would develop civil nuclear energy (Xu, 2010). This led to the construction of the 300 MW Qinshan I plant in Zhejiang based on Chinese design, though with key imported components, and two 944 MW units at Daya Bay in Guangdong Province, of French design, with China Light and Power of Hong Kong as the joint-venture partner. These plants came into commercial operation in 1994. The government then decided to build four more plants with designs from four countries: USA, Canada, Russia and France (Xu, 2010).

In the early years of the twenty first century, the need for large-scale, low-emission base load triggered a revival of interest in nuclear power, as was the case with hydroelectricity. The *Medium to Long Term Plan for Nuclear Energy Development 2005–2020* presented the aim of having 45 GW in operation by 2020, with new plants both along the coast and at inland locations experiencing rapid economic growth (Xu, 2010). The target for the year 2020 was raised to 80 GW in the *Five-Year Plan* for 2011–2015. By this time, there were three Chinese companies developing and investing in nuclear power and the government was providing a feed-in-tariff for nuclear power that was significantly above that for thermal power (Rutkowski, 2013).

The Fukushima Daiichi disaster in 2011 brought a temporary halt to this programme. Construction of all new plants was suspended, all plants in operation or under construction were subject to a safety inspection and plans to construct plants at inland locations were set aside. The government permitted the construction of coastal plants to restart in late 2012, but it reduced the capacity target for 2020 to 58 GW, down from 80 GW (Xu, 2014). By the end of 2017, 35 GW of capacity was in operation and more than 20 GW under construction (World Nuclear Association, 2018). A large proportion of these plants are CPR-1000's which are Chinese indigenous upgrades of the French designs used at Daya Bay. In addition, a number of third generation plants were in the final stages of construction in 2018: namely, two Westinghouse AP-1000s, one EDF European Pressured Reactors, one Russian VVER-1000, and two Chinese Hualong 1 reactors (World Nuclear Association, 2018).

China's programme for nuclear power is by far the most ambitious in the world. The planned rate of capacity growth may exceed that of the USA at its peak, which amounted to 42 GWe brought into operation between 1969 and 1977. Even without this rapid expansion, citizens of China and of neighbouring countries would be quite justified in having concerns about the government's ability to regulate the safety of construction and operation of these plants, and the integrity of the supply chains (Xu, 2014).

4.2 Wind and Solar Energy

China is endowed with rich wind and solar energy resources, but these are mainly concentrated in the north and west of the country, far from the main centres of demand in the east. The initial motivations for supporting the development of wind and solar energy in the 1980s were rural electrification and poverty alleviation (Pan et al., 2006). The growing recognition of the health consequences of coal combustion led to environmental concerns becoming a more significant driver in the 1990s (Yang et al., 2003; Lema and Ruby, 2007). By the early years of the twenty-first century, further impetus came from the desire to develop domestic manufacturing capacity in wind and solar energy (Zhang et al., 2013). As a result, national research and development agencies started to direct significant funding to wind and solar energy from 2001 onwards (Andrews-Speed and Zhang, 2015).

The *Renewable Energy Law* of 2005 marked a turning point for China's renewable energy industry and the start of a period of massive growth. The new law was reinforced by a number of subsequent policies such as the establishment of a *Special Fund for Renewable Energy Development*, successive five-year plans for renewable energy development with targets for capacity, the *Medium and Long-Term Plan for Renewable Energy Development 2007* and an update of the *Catalogue of Chinese High-Technology Products for Export* (Zhang et al., 2013).

Together, these and other policies provided a wide range of incentives for actors along the full length of the supply chains for wind and solar energy (Zhang et al., 2013; Andrews-Speed and Zhang, 2015). The *Special Fund* provided support for research and development and for manufacturing. The Ministry of Science and Technology targeted their funding at the development of progressively larger wind turbines, from 600 kW in *Ninth Five-Year Plan* (1996–2000) to 2–3 MW in *Eleventh Five-Year Plan* (2006–2010). Targets were set for installed capacity. Subsidies were available to project developers for constructing wind farms and to the grid companies for integrating renewable energy. The *Renewable Energy Law* introduced the concept of mandatory market share for any generating company with more than 5 GW of total capacity. Grid companies were mandated to provide wind power and solar PV installations access to the grid, not just connection but also dispatch and ancillary services. In return, additional costs could be shared between the grid and end-users. The initial scheme for on-grid tariffs allowed the tariffs to set by the NDRC or through concession bidding.

The revised *Renewable Energy Law* of 2009 paved the way for the NDRC to issue a notice on improving the price policy for wind power generation through the introduction of feed-in-tariffs. These tariffs depended on the quality of the regional wind resources. The government introduced feed-in-tariffs for solar PV in 2011, once the costs of the equipment had declined sufficiently. Finally, this period saw an increasing use of the Clean Development Mechanism which had been applied to 568 wind power projects in China by end of 2010 (Zhang, 2011).

The generous availability of state funds, together with the support of local governments has led to China becoming a world leader in the manufacturing and installation of wind energy and solar PV capacity. These incentives attracted a large number of local state-owned enterprises and private entrepreneurs into the manufacturing of renewable energy equipment, leading to China gaining a 46% share of the global market for solar PV and a 24% share of the market for wind energy equipment in 2016 (REN21, 2017). China's installed capacity of wind energy increased almost tenfold between 2009 and 2017 to reach 163 GW and the capacity of solar PV grew twenty-fold from 2012 to reach 130 GW by the end of 2017 (National Energy Administration, 2018a).

The main challenges facing wind energy have been grid connection and curtailment. Between 2006 and 2009, the share of wind energy capacity that was connected to the grid fell from 81% to 68%. The same period saw a rise in wind turbine disconnection and breakdown. The rate of curtailment has generally been above 10% since 2011, and in 2017 reached 12% or 41.9 TWh. Curtailment rates in 2017 varied from 14% in Heilongjiang Province, 15% in Inner Mongolia, to 21% in Jilin, 29% in Xinjiang, and 33% in Gansu (National Energy Administration, 2018b). Solar PV installations have suffered from similar problems. Curtailment of solar PV is particularly prominent in the five underpopulated and remote north-west provinces of the country, where 40% of the installed capacity is located. Curtailment in 2017 reached 22% in Xinjiang, 20% in Gansu and 9% in Shaanxi. Ningxia and Qinghai performed better with curtailment levels of 6% (National Energy Administration, 2018b).

The sources of these deficiencies are multiple and lie in the policy and planning processes, in certain characteristics of the national electricity sector, and in the interests of the various actors. Although government carries out planning, final project approvals are issued at local level. Local economic interests have led to renewable energy capacity outstripping grid capacity (Davidson et al., 2017). These challenges have been exacerbated by the focusing of planning targets on installed capacity rather than electricity delivered, and by the low level of coordination between the grid companies and the project developers, with the NDRC failing to exert their authority (Zhang et al., 2013).

Two fundamental features of China's power industry contributed to the high level of curtailment. The first was the paucity of flexible power to match the intermittency of wind and solar energy, arising from the shortage of gas fired power stations and pumped-storage hydro, and the lack of incentives for coal-fired stations to increase their flexibility (Zhang et al., 2015; Zhao et al., 2016; Yin et al., 2017). Secondly, it is difficult to trade power across the country between balancing areas, as planning and dispatch tends to be executed at provincial level (Davidson et al., 2017).

These deficiencies have been aggravated by a number of technical issues, some of which have their origins in the interests and abilities of key actors. The technical standard of the turbines remains below what is required, the major problem being the tolerance to the large quantity of sand and dust in the air. Manufacturing companies have been spending insufficient funds on research and development because their profits are being squeezed by the highly competitive market (Zhao et al., 2016). Project developers try to build wind farms as fast as possible in order to occupy prime land and secure future market position. To keep up this level of investment, they require manufacturers to supply at low cost and so often end up purchasing low quality equipment (Zhao et al., 2016).

Solar PV panels also suffer from technical problems that result in low efficiency. A government study showed that out of the 425 solar PV stations from 32 provinces investigated, 30% of installations three years or older exhibited various quality defects. These defects caused attenuation rates as high as 68% for systems that had been operational for as little as three years (Anonymous, 2018). Further, the government has established no industrial or national standards for solar PV maintenance of December 2017. Instead, chaotic price competition in the solar PV maintenance market has frequently resulted in low solar system efficiency (Sun et al., 2017). These deficiencies in the solar PV systems are exacerbated by the accumulation on the panels of dust from nearby fields and deserts, and by the filtering effect of the air pollution which is particularly heavy in winter.

Arguably, it has been local governments that have played the most active role in the implementation of wind energy policy on account of their prioritisation of local economic development, employment and tax revenues. They have provided over-generous support for manufacturing and installation but have given too little backing for grid connection and dispatch. The overcapacity in wind turbine manufacturing has arisen from local protectionism, as wind farm developers tend to buy from local manufacturers to obtain project approvals from local governments (Zhao et al., 2016).

Local governments have also played a central role in the curtailment of wind power and grid connected solar PV as they tend to give preference to dispatching thermal plants over intermittent renewable energy. The number of hours of generation for thermal plants is still determined by local governments after negotiation to create annual plans, which are then implemented by local system operators. Thermal power stations lose out if the local grid operator dispatches wind energy preferentially, as is required by the central government, for a reduction of operating hours raises the breakeven price (Davidson et al., 2017). Recent years have seen the emergence of local overcapacity in power generation. In 2016, the average coal-fired power station in China was operating at a capacity factor below 50%. Thermal plants employ more people and generate more local tax revenue than wind farms (Zhao et al., 2016). As a result, wind and solar energy have not been given priority dispatch in all provinces (Davidson et al., 2017).

5 Conclusions

China's strategies to support a low-carbon energy transition and reduce air pollution by constraining the role of fossil fuels in the energy mix have met with a high degree of success since 2005. The proportion of fossil fuels in primary energy supply declined from 94% in 2005 to 86% in 2017. Over the same period, the share of low-carbon energy sources in power generation grew from 18% to 29%. These include hydroelectricity, nuclear power, and wind and solar energy. In addition, the efficiency of coal combustion has improved, and natural gas is slowly replacing coal in some sectors. Much of this success has been achieved through the deployment of the government's traditional administrative policy instruments supplemented by substantial financial support. Such an approach is consistent with the wider political institutions of governance as well as the institutions that govern the energy sector. However, although the use of coal seems to be close to reaching a permanent plateau, the total primary energy demand continues to rise and this, in turn, results in the ongoing, though slowing, rise of fossil fuel consumption in the form of oil and natural gas.

The country has great potential for the further deployment of wind and solar energy. There is also the scope to boost the share of natural gas. However, both sets of opportunities are being constrained by a range of factors both within the wider institutional environment and within the energy sector itself. Of special significance are the ability of local governments to undermine central government policies, the power of the state-owned energy companies, and the way in which the power sector is governed. China's current leadership has been bringing in a number of reforms to the oil and gas industry and to the power sector and is preparing to launch a nationwide carbon emissions trading scheme in 2020. In the meantime, the low cost of domestic coal and the growing demand for oil in the transport and petrochemical sectors will continue to underpin the demand for fossil fuels.

The key determinants of the pace at which China reduces its use of fossil fuels in absolute terms are two-fold. First, and of greatest importance, is the rate of economic growth. Coal has long been the swing fuel and an increase in economic growth has always boosted coal consumption. Social stability and therefore employment are high political priorities. So, the government continues to react to economic slowdown by injecting funds into the economy, but no longer on the scale of that seen in 2009. Nevertheless, every additional expenditure on infrastructure is likely to boost coal consumption.

The second key variable is the mix of market and administrative policy instruments deployed. The success of programmes to suppress fossil fuel consumption to date has relied to a great extent on the continued importance of state ownership and direct financial support, and the deployment of administrative policy instruments. Whilst the continued introduction of market forces into the energy sector may be welcome on purely economic grounds in principle, it is not evident that they will be effective at enhancing efficiency or reducing emissions for as long as the major energy producing and consuming enterprises remain in state hands. The current leadership shows no sign of planning to privatise the state-owned energy companies. Quite the opposite, they may be assigned yet more non-commercial obligations. Meanwhile, the long-preferred administrative instruments and subsidies appear to be yielding diminishing returns. The large-scale deployment of CCS/U remains a long way off. As a result, the absolute reduction in the use of fossil fuels in China is likely to be a long process relying on sustained policy pressure from the government in support of alternative forms of energy.

References

Andrews-Speed, P. 2004. *Energy Policy and Regulation in the People's Republic of China*. London: Kluwer Law International.

Andrews-Speed, P. 2012. *The Governance of Energy in China: Transition to a Low-Carbon Economy*. London: Palgrave Macmillan.

Andrews-Speed, P. 2016. Applying Institutional Theory to the Low Carbon Transition. *Energy Research and Social Science* 13: 216–225.

Andrews-Speed, P. and Zhang, S. 2015. Renewable Energy Finance in China. In: Donovan, C.W. (Ed.) *Renewable Energy Finance*. London: Imperial College Press, pp. 175–194.

Anonymous. 2018. The National Energy Administration Answered the Reporter's Question: After the 531 New Deal, the Five Major Policies and Measures Promote the Healthy Development of the Photovoltaic Industry. https://api.dltoutiao.com/home/html/3/225328?.

Askci Consulting. 2018. China's CBM Production Data Analysis from January to December 2017: Cumulative Growth of 8.2%. January 24, 2018. http://www.askci.com/news/chanye/20180124/102103116728.shtml# (in Chinese).

Bloomberg News. 2018. Next Up in China's Clean-Air Push Is a Gas Pipeline Behemoth. *Bloomberg News*, June 11, 2018. https://www.bloomberg.com/news/articles/2018-06-11/next-up-in-china-s-clean-air-push-is-a-gas-pipeline-behemoth.

BP. 2018. *Statistical Review of World Energy*. London: BP.

Caldecott, B., Dericks, G., Tulloch, D.J., Liao, X., Kruitwagen, L., Bouveret, G. and Mitchell, J. 2017. Stranded Assets and Thermal Coal in China. An Analysis of Environment-Related Risk Exposure. University of Oxford, Smith School of the Environment, Sustainable Finance Programme, Working Paper.

Davidson, M.R., Kahrl, F. and Karplus, V.J. 2017. Towards a Political Economy Framework for Wind Power: Does China Break the Mould?. In: Arent, D., Arndt, C., Miller, M., Tarp, F. and Zinaman, O. (Eds.) *The Political Economy of Clean Energy Transitions*. Oxford: Oxford University Press, pp. 250–270.

Dittmer, L. 2017. Xi Jinping's "New Normal": Quo Vadis? *Journal of Chinese Political Science* 22: 429–446.

Dong, X., Pi, G., Ma, Z. and Dong, C. 2017. The Reform of the Natural Gas Industry in the PR of China. *Renewable and Sustainable Energy Reviews* 73: 582–593.

Economy, E. 2004. *The River Runs Black. The Environmental Challenge to China's Future*. Ithaca, NY: Cornell University Press.

Finamore, B. and Szymanski, T.M. 2002. Taming the Dragon's Head: Controlling Air Emissions from Power Plants in China—An Analysis of China's Air Pollution Policy and Regulatory Framework. *Environmental Law Reporter* 32 (11439): 26.

Geall, S. and Ely, A. 2015. Innovation for Sustainability in a Changing China: Exploring Narratives and Pathways. STEPS Working Paper 86, STEPS Centre, Brighton.

Grubb, M, Sha, F., Spencer, T., Hughes, N., Zhang, Z. and Agnalucci, P. 2015. A Review of Chinese CO_2 Emission Projections to 2030: The Role of Economic Structure and Policy. *Climate Policy* 15 (S1): S7–S39.

Grunberg, N. 2017. Revisiting Fragmented Authoritarianism in China's Central Energy Administration. In: Brodsgaard, K.J. (Ed.) *Chinese Politics as Fragmented Authoritarianism. Earthquakes, Energy and Environment*. London: Routledge, pp. 15–37.

Howell, J. 2006. Reflections on the Chinese State. *Development and Change* 37: 273–297.

Hu, B. and Zhai, H. 2017. The Cost of Carbon Capture and Storage for Coal-Fired Plants in China. *International Journal of Greenhouse Gas Control* 65: 23–31.

Huang, B., Xu, S., Gao, S., Liu, L., Tao, J., Niu, H., Cai, M. and Cheng, J. 2010. Industrial Test and Techno-Economic Analysis of CO_2 Capture in Huaneng Beijing Coal-Fired Power Station. *Applied Energy* 87: 3347–3354.

International Energy Agency. 2016. *Ready for CCS Retrofit. The Potential for Equipping China's Existing Coal Fleet with Carbon Capture and Storage*. Paris: OECD/IEA.

International Energy Agency. 2017. *World Energy Outlook 2017*. Paris: OECD/IEA.

Jing, J.. 1997. Rural Resettlement: Past Lessons for the Three Gorges Dam Project. *The China Journal* 38: 65–92.

Kambara, T. and Howe, C. 2007. *China and the Global Energy Crisis. Development and Prospects for China's Oil and Natural Gas*. Cheltenham: Edward Elgar.

Lema, A. and Ruby, K. 2007. Between Fragmented Authoritarianism and Policy Coordination: Creating a Chinese Market for Wind Energy. *Energy Policy* 35: 3879–3890.

Leutert, W. 2018. The Political Mobility of China's Central State-Owned Enterprise Leaders. *The China Quarterly* 233: 1–21.

Li, C. 2015. *China's Centralized Industrial Order. Industrial Reform and the Rise of Centrally Controlled Big Business*. London: Routledge.

Lieberthal, K.G. 1995. *Governing China. From Revolution Through Reform*. New York: W.W. Norton.

Lieberthal, K.G. and Oksenberg, M. 1988. *Policy Making in China. Leaders, Structures and Processes*. Princeton: Princeton University Press.

Liu, C. 2018a. *Report on Domestic and Foreign Oil and Gas Industry Development in 2017*. Beijing: Oil and Gas Press.

Liu, H. 2018b. Carbon Capture and Storage in Decarbonising the Chinese Economy. Global CCS Institute, Insights, June 5, 2018. http://status.globalccsinstitute.com/insights/authors/GlobalCCS%20Institute/2018/06/05/carbon-capture-and-storage-de-carbonising-chinese-economy?author=NDU3MTE4

Ma, C. and Zhao, X. 2015. China's Electricity Market Restructuring and Technology Mandates: Plant-Level Evidence for Changing Operational Efficiency. *Energy Economics* 47: 227–237.

Mao, J. 2009. The Status and Development of Supercritical/Ultrasupercritical Units in China. In: *34th International Technical Conference on Coal Utilization & Fuel Systems*, 31 May–4 June 2009, Clearwater, Florida.

Matthews, J.A. and Tan, H. 2015. *China's Renewable Energy Revolution*. Basingstoke: Palgrave Macmillan.

Myllyvyrta, L. and Shen, X. 2016. *Burning Money. How China Could Squander Over One Trillion Yuan on Unneeded Coal-Fired Capacity*. Beijing: Greenpeace.

Na, C., Yuan, J., Xu, Y. and Hu, Z. 2015. Penetration of Clean Coal technology and Its Impact on China's Power Industry. *Energy Strategy Reviews* 7: 1–8.

National Bureau of Statistics. 2017. *China Statistical Yearbook 2017*. Beijing: National Bureau of Statistics.

National Bureau of Statistics. 2018. Statistical Communique on National Economic and Social Development 2017, February 28, 2018. http://www.stats.gov.cn/tjsj/zxfb/201802/t20180228_1585631.html (in Chinese).

National Development and Reform Commission. 2018. Draft Measures for Fair and Open Supervision of Oil and Gas Pipeline Network Facilities, August 3, 2018. http://www.ndrc.gov.cn/zwfwzx/tztg/201808/t20180803_895250.html (in Chinese).

National Energy Administration. 2018a. New Installed Capacity of Solar PV Reached 53.05 GW, Taking the Lead in All Renewable Energy Sources. January 24, 2018. http://www.nea.gov.cn/2018-01/24/c_136920159.htm (in Chinese).

National Energy Administration. 2018b. The Situation of Grid-Connection of Wind Power in 2017. February 1, 2018. http://www.nea.gov.cn/2018-02/01/c_136942234.htm (in Chinese).

North, D.C., Wallis, J.J. and Weingast, B.R. 2009. *Violence and Social Orders*. Cambridge: Cambridge University Press.

Nyman, J. and Zeng, J. 2006. Securitization in Chinese Climate and Energy Politics. *WIRES Climate Change* 7: 301–312.

Pan, J., Peng, W., Li, M., Wu, X., Wan, L., Zerriffi, H., Elias, B., Chi, Z. and Victor, D. 2006. Rural Electrification in China 1950–2004. Historical Forces and Key Driving Processes. Program on Energy and Sustainable Development, Working Paper No. 60, Stanford University.

Qin, Y., Tong, F., Yang, G. and Mauzerall, D. 2018. Challenges of Using Natural Gas as a Carbon Mitigation Option in China. *Energy Policy* 117: 457–462.

REN 21. 2017. *Renewables 2017. Global Status Report*. Paris: REN21

Rutkowski, R. 2013. The Economics of Nuclear Power in China. *China Economic Watch*, Petersen Institute for International Economics. https://piie.com/blogs/china-economic-watch/economics-nuclear-power-china.

Sandalow, D., Akos, L. and Sheng, Y. 2018. A Natural Gas Giant Awakens: China's Quest for Blue Skies Shapes Global Markets. *China Natural Gas Commentary*, Columbia SIPA, Center on Global Energy Policy.

Senior, B., Wenying, C., Gibbins, J., Haydock, H., Li, M., Pearce, J., Su, W. and Ulanowsky, D. 2011. Carbon Capture and Storage in China—Main Findings from China-UK Near Zero Emissions Coal (NZEC) Initiative. *Energy Procedia* 4: 5956–5965.

Shapiro, J. 2001. *Mao's War Against Nature: Politics and the Environment in Revolutionary China*. Cambridge: Cambridge University Press.

Shearer, C., Mathew-Shah, N., Myllyvyrta, L., Yu, A. and Nace, T. 2018. *Boom and Bust 2018. Tracking the Global Coal Plant Pipeline*. Coalswarm/Sierra Club/Greenpeace.

Shi, X. and Varium, H.M.P. 2015. China's Gas Market Liberalisation. The Impact on China-Australia Gas Trade. In: Song, L., Garnaut, R., Fang, C. and Johnston, L. (Eds.) *China's Domestic Transformation in a Global Context*. Acton: ANU Press, pp. 137–174.

Sovacool, B.K. and Valentine, S.V. 2012. *The National Politics of Nuclear Power*. London: Routledge.

Sun, Y. 2017. *China's Emissions Trading Report*. Beijing: Social Science Academic Press (in Chinese).

Sun, H., Li, S. and Li, P. 2017. Disorderly Solar PV Operation and Maintenance Market: How Would the 10 Billion Solar PV Operation and Maintenance Market Grow. *China Energy* 2017 (11): 43–48 (in Chinese).

US Energy Information Administration. 2018. International Energy Statistics. https://www.eia.gov/.

Vermeer, E.B. 2012. Hydropower in China: Development or Slowdown. International Institute for Asian Studies, Leiden, Newsletter 62 (Winter 2012): 36.

Viebahn, P., Vallentin, D. and Holler, S. 2015. Prospects of Carbon Capture and Storage (CCS) in China's Power Sector—An Integrated Assessment. *Applied Energy* 157: 229–244.

Williamson, O.E. 2000. The New Institutional Economics: Taking Stock and Looking Ahead. *Journal of Economic Literature* 37: 595–613.

World Nuclear Association. 2018. *Nuclear Power in China*. London: World Nuclear Association.

Xu, Y-C. 2002. *Powering China. Reforming the Electrical Power Sector in China*. Aldershot: Ashgate.

Xu, Y-C. 2010. *The Politics of Nuclear Energy in China*. Basingstoke: Palgrave Macmillan.

Xu, Y-C. 2014. The Struggle for Safe Nuclear Expansion in China. *Energy Policy* 73: 21–20.

Yang, H., Wang, H., Yu, H., Xi, J., Cui, R. and Chen, G. 2003. Status of Photovoltaic Industry in China. *Energy Policy* 31: 703–707.

Yeager, B. 2016. Pushing the Ultra Envelope: Advanced Power Technologies are Mainstream in China. *Power Magazine*, January 11, 2016. http://www.powermag.com/pushing-ultra-envelope-advanced-power-technologies-mainstream-china/

Yeh, E.T. and Lewis, J.I. 2004. State Power and the Logic of Reform in China's Electricity Sector. *Pacific Affairs* 77: 437–465.

Yin, S., Zhang, S., Andrews-Speed, P. and Li, W. 2017. Economic and Environmental Effects of Peak Regulation Using Coal-Fired Power for the Priority Dispatch of Wind Power in China. *Journal of Cleaner Production* 162: 361–370.

Yuan, J., Na, C. and Yang, M. 2016a. Energy Efficiency and Conservation in China's Power Sector: Progress and Prospects. In: Bin, S. and Thomson, E. (Eds.) *China's Energy Efficiency and Conservation. Sectoral Analysis*. Singapore: Springer, pp. 5–21.

Yuan, J., Li, P., Wang, Y., Liu, Q., Shen, X., Zhang, K. and Dong, L. 2016b. Coal Power Overcapacity and Investment Bubble in China During 2015–2020. *Energy Policy* 97: 136–144.

Zhang, Z. 2011. *Energy and Environmental Policy in China. Towards a Low-Carbon Economy*: Cheltenham: Edward Elgar.

Zhang, S. and Qin, X. 2016. Promoting Large and Closing Small in China's Coal Power Sector 2006–2013: A CO_2 Mitigation Assessment Based on a Vintage Structure. *Economics of Energy & Environmental Policy* 5 (2): 85–99.

Zhang, S., Zhao, X., Andrews-Speed, P. and He, X. 2013. The Development Trajectories of Wind Power and Solar PV Power in China: A Comparison and Policy Recommendations. *Renewable and Sustainable Energy Reviews* 26: 322–331.

Zhang, S., Andrews-Speed, P. and Perera, P. 2015. The Evolving Policy Regime for Pumped Storage Hydroelectricity in China: A Key Support for Low-Carbon Energy. *Applied Energy* 150: 15–24.

Zhao, X., Li, S., Zhang, S., Yang, R. and Liu, S. 2016. The Effectiveness of China's Wind Power Policy: An Empirical Analysis. *Energy Policy* 95: 269–279.

Zheng, Y. 2010. *The Chinese Communist Party as Organizational Emperor. Culture, Reproduction and Transformation*. London: Routledge.

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Managing the Decline of Fossil Fuels in a Fossil Fuel Intensive Economy: The Case of The Netherlands

Sem Oxenaar and Rick Bosman

1 Introduction

The use and combustion of fossil fuels has been the main contributor to anthropogenic greenhouse gas (GHG) emissions over the last decades, making up around 78% of total GHG emissions globally (IPCC, 2014). To stay within the 2 degree, and preferably 1.5 degree average global temperature increase compared to pre-industrial levels set as the goal under the Paris Climate Agreement (Paris Agreement, 2015), a large part of current fossil fuel reserves—around a third of oil reserves, half of all natural gas (gas) reserves, and around 80% of global coal reserves—will need to remain unused (Jakob and Hilaire, 2015; McGlade and Ekins, 2015). Current climate policies put us on a pathway towards at least 3 degrees of global warming by 2100 (Climate Action Tracker, 2017; van Vuuren et al., 2017). Thus, to prevent dangerous climate change a rapid shift towards an energy system based on renewable and low-carbon sources is necessary. Lacking large-scale carbon capture and storage (CCS), fossil fuel use will need to be brought down drastically. Given the pervasiveness of fossil fuels in the (global) economy and its embeddedness in our daily lives this will involve enormous societal change, and radically alter the nature of our economy and change the way in which we produce, consume, and live.

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The Netherlands has been a slow adopter of renewable energy (RE), currently ranking 2nd last in the European Union when it comes to share of RE in the energy mix, with 6% RE (Eurostat, 2017). Historically, fossil fuels are important for the Netherlands, being a large producer of natural gas, functioning as a trade hub for oil, coal, and gas, and as a refining centre for (North) West Europe. Compared to other countries in the Organisation for Economic Co-operation and Development (OECD) the Dutch economy is fossil fuel and GHG intensive (IEA, 2014, p. 10), with over 90% of the total primary energy supply coming from fossil fuels, and with energy intensive industries contributing around 12.5% of GDP (Weterings et al., 2013). Moreover, the countries GHG emissions have been rising since 2015, mainly due to greater use of coal and gas fired power plants (Schoots et al., 2017). Although current developments around wind energy, with the first 'subsidy-free' offshore wind park announced for 2022 (Rijksoverheid, 2018a), current natural gas production caps, and a planned production stop in 2030 for country's largest 'Groningen' gas field due to earthquakes and the resulting societal impacts (Rijksoverheid, 2018b), do have the potential to accelerate the energy transition in the Netherlands, the country will likely not meet its set goal of 14% RE in 2020 (Schoots et al., 2017).

This position as a fossil fuel intensive country and trading hub with rising GHG-emissions is especially interesting given the Netherlands long history of policymaking aimed at GHG-reduction and the expansion of renewable energy. Verbong and Geels (2007) argue that, for a multiplicity of reasons, the Dutch government initiated the energy transition in the Netherlands in the 1970s. Moreover, in the early 2000s, with the fourth National Environmental Policy Plan, the government officially adopted a strategy of 'transition management' (TM) in order to transform the dominant fossil fuel based energy system and accelerate the uptake of renewable energy (Van der Loo and Loorbach, 2012: 221–222).

In sustainability transitions literature, on which this chapter builds, it has been hypothesised that the influence of fossil fuel incumbents in the energy system and strong government-industry ties have contributed to this slow development of renewable energy in the Netherlands compared to other European countries. The energy regime—the current culture, structure, and practices involved in providing the function energy—has shown a strong degree of 'lock-in'. Based on a long history of natural gas production and the build-up of related institutions (Correljé and Verbong, 2004), with the government having played an active role in shaping the energy system by introducing gas and nuclear (Van der Loo and Loorbach, 2012), and incumbent actors partially capturing earlier transition policy attempts (Kern and Smith, 2008; Smink, 2015), evidence suggests that the government, or parts of it, has itself exhibited 'incumbent behaviour', thus strengthening the current regime (Bosman et al., 2014; Van der Loo and Loorbach, 2012). Yet, transitions literature also sees an important role for governments in sustainability transitions, especially in the early stages of a transition (Geels, 2011; Meadowcroft, 2009; Rotmans et al., 2001; van den Bergh, 2013; Verbong and Loorbach, 2012). As such, strong ties between governments and fossil fuel industries could be problematic (Oxenaar, 2017). In a first step towards testing this hypothesis this chapter reports on a study into the question: what financial interdependencies exist between the Dutch government and the fossil fuel industry?[1]

This chapter provides a summary of the findings of this study (Oxenaar, 2017) and explores their relevance to the discussion around a managed decline of fossil fuels. To do this it first provides some relevant insights from transitions theory, such as multi-actor dynamics, then moving on to a description of the methodology used in the mapping exercise, a summary of the found relationships, and a reflection and discussion of the results and their relevance for a managed decline.

2 Sustainability Transitions and Managed Decline

Sustainability transitions are large-scale fundamental societal changes towards sustainability, such as developing a low-carbon energy system. They involve a change in 'regimes', from one set of dominant structures, institutions, practices, paradigms, and economics, to another (Verbong and Loorbach, 2012: 9; Van Raak, 2015). For the energy system, the regime consists of a network of actors and social groups, such as the government, the incumbent fossil based energy suppliers, and users of energy, combined with established practices and rules that guide the activities of these actors, e.g. laws, regulations, and societal norms, and the material and technical elements such as the electricity grid or power plants (Verbong and Geels, 2007). Regimes have a large historical aspect, develop path dependency, and are characterised by a high degree of lock-in. An important factor is that incumbent actors have vested interests in the status quo and social capital has been built up around it leading to a fixed idea about their 'role' in society. Adding to this, the existing

[1] The case study in this chapter is a summarised and adapted version of the following study: Oxenaar, S. 2017. Mapping the Financial and Organizational Interdependencies between the Dutch State and the fossil fuel industry. Master Thesis, Humboldt University Berlin and DRIFT, Erasmus University Rotterdam.

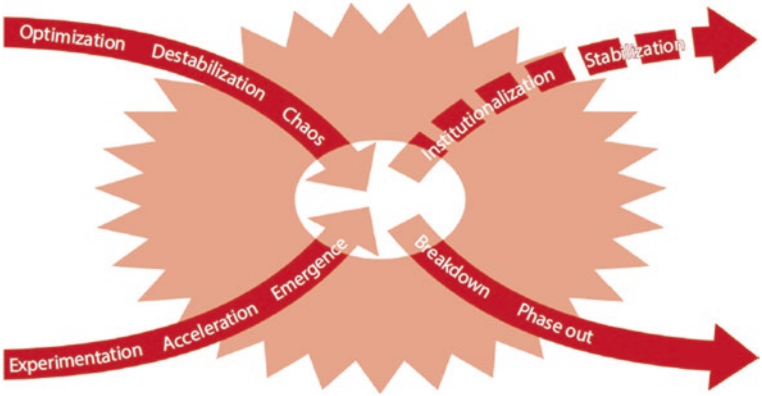

Fig. 6.1 Transition dynamics—X curve. (Source: Loorbach et al., 2017)

'rules of the game' have a stabilising effect on the system and habitual behaviour and shared mindsets and beliefs can contribute to 'cognitive inertia' which might impede actor's sensitivity to other ways of doing. Moreover, existing investments in technology, connected sunk costs, and the complementary nature of the technologies in use, further stabilises existing energy infrastructure (Turnheim and Geels, 2013; Verbong and Geels, 2007).

The shift in regimes is driven by persistent problems in the energy system, such as high GHG-emissions and ambient air pollution, and takes place over a period of decades (Loorbach et al., 2017: 2). Over 25–50 years, transitions generally follow a pattern of build-up and breakdown. 'New' practices emerge and are eventually institutionalised, and 'old' practices are disrupted and phased-out over time (Fig. 6.1). Traditionally, most attention in (sustainability) transition studies has been given to niche-regime interactions and pathways of build-up. However, with the energy transition advancing dynamics of 'destabilisation', 'breakdown', and 'chaos' are becoming more relevant and increasingly studied.[2]

Given the large-scale changes implied in transitions, they are by definition multi-actor processes, involving a multitude of actors from different institutional backgrounds—such as state, market, civil society and science. Changes in role constellations and power relations between these different actors are an important dynamic of a system in transition (Avelino and Wittmayer, 2016; Loorbach et al., 2017: 16). Part of the regime lock-in is thus due to existing power relations, further strengthening the path dependency. In the political economy literature, and now taken up by transitions literature, this has been conceptualised as an unconscious 'alliance' between policymakers and incumbent firms directed at maintaining the status quo in the system (Geels, 2014;

[2] See for example: (Bosman et al., 2014; Karltorp and Sandén, 2012; Turnheim and Geels, 2012, 2013).

Levy and Newell, 2002; Unruh, 2000). It is 'unconscious' in the sense that there is no 'official' or explicit agreement existing between government and incumbent parties that outlines the alliance. Rather, it arises from, on the one hand, society being reliant on growth, and large businesses being able to provide the capital necessary for this, providing an incentive for governments to accommodate them, and, on the other hand, these capital providers being dependent on governments that shape the market and playing field through rules and regulations (Geels, 2014). For the energy system this could take the form of a 'fossil fuel historical bloc' an implicit cooperation between governments, fossil fuel companies, and trade bodies based on existing, underlying, interdependencies. For example, governments need fossil fuel producers to extract their resources while producers need governments to gain access to these resources (Phelan et al., 2013). The existence of such a bloc would exert a strong stabilising force on the energy system, dampening the potential for change and non-fossil fuel-based innovation.

It is because of these multi-actor dynamics, as experience from 'transition management' shows, that transitions cannot be directly controlled and steered but only influenced in their speed and direction (Loorbach, 2009). Governance in such systems is a multi-actor process in which experimenting and learning shapes solutions, innovations, and institutions. Although a government is seen by some as a necessary catalyst in the initial stages of sustainability transitions, its agency in governing transitions might also be limited by the multi-actor dynamics and, for the energy system, the possibility of a 'fossil fuel bloc'. This has ramifications for the possibility of a managed 'decline' or 'phase-out' of fossil fuels. Firstly, when speaking of a 'managed' decline, who is supposed to do the 'managing'? If management is 'distributed' across a multitude of societal actors, as transition management implies, to what extent can governments manage a decline of fossil fuels? What would this management entail? The lessons from TM show that this could mainly focus on providing directional guidance, for example by setting an end date for fossil fuel production or accelerating/decelerating existing dynamics in the phase-out and breakdown 'pathway' of transitions.

3 Methodology

To structurally map the financial and ownership relationships between government and the fossil fuel industry an operational framework has been developed based on the fossil fuel value chain and inspired by studies on sectoral analysis.[3] This resulted in a framework with seven stages: In the initial scoping

[3] See, for example: (Moncrieffe and Luttrell, 2005).

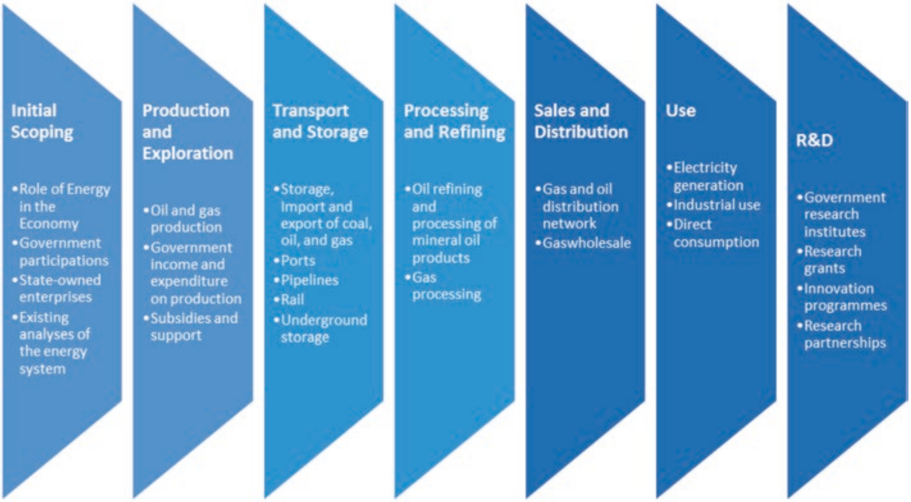

Fig. 6.2 Seven stage framework for the analysis of government-fossil fuel industry relationships. (Source: Oxenaar, 2017)

stage the role of fossil fuels in the economy was analysed by looking at existing studies to identify areas where financial linkages would be likely (Fig. 6.2). Stages one to six—production and exploration, transport and storage, processing and refining, sale and distribution, use, and research & development (R&D)—looked at specific segments of the value chain and R&D. For each stage a set of 'core' topics and questions were developed in an iterative manner by going back and forth between the data and the framework during the process (Oxenaar, 2017).

For the initial scoping, data from statistics agencies and existing analyses of the Dutch energy system were used. The other stages relied mainly on data from: government documents and websites, annual-reports, -accounts, and -budgets of municipalities, provinces, and the national government; annual-reports of websites and studies of and by state owned enterprises (SOEs); data from trade associations; tax data; and reports and accounts of government agencies. The study looked at the period 2001 to 2015 (Oxenaar, 2017).

4 Government—Fossil Fuel Industry Interdependencies

This section provides a summary of the most important findings of the government-industry relations study, looking at government income and expenditure and the relationships found in each segment of the fossil fuel value chain (Oxenaar, 2017). The Dutch government was found to be related to the fossil fuel industry through revenue and expenditure and asset ownership, but also plays an important role in the industry itself. Through SOEs and participations, it is directly involved in the exploration, production, transport and storage, processing, sale, and distribution of oil and gas. Examples of these are the SOE *EBN* through which the State has a stake of at least 40% in all oil and gas production in the country, the publicly owned Dutch ports which facilitates fossil fuel trading and related activities, or the SOE *Gasunie* and regional transmission networks through which the state is involved in gas transport and distribution.

4.1 Government Fossil Fuel Related Income and Expenditure

Historically the Dutch government is very reliant on income from fossil fuels and related activities coming in through a host of different taxes, dividends, royalties, levies, and fees. On average, between 2001 and 2015, this brought in at least €21.5 billion a year.[4] This makes up about 14% of the governments freely spendable income (total government revenue minus social insurance premiums) on average over those years. In 2015, €5.26 billion came from the production and exploration segment, €437 million from transport and storage, €13.6 million from sales and distribution, and €14.35 billion from the use of fossil fuels (Fig. 6.3).

Figure 6.3 shows that until 2013 income from fossil fuel related activities was growing steadily, 7% average year on year growth, both in absolute terms and as share of spendable income. Also noticeable is that, due to the sharp fall in income from oil and gas production, income from the use of fossil fuels is becoming increasingly important as a revenue source. The data series analysed in this study only ran up to 2015, but government income from oil and gas production has continued to decline in 2016 to €2.85 billion, and decreased slightly to €2.82 billion in 2017 (CBS, 2018a).

On the other hand, the government also has expenditure on fossil fuel related activities (Fig. 6.4). For example, through tax exemptions and returns, compensation subsidies, R&D subsidies, and support measures for gas pro-

[4] This is a low estimate since several revenue sources such as income and corporate tax from fossil fuel related activities and VAT on electricity (88% fossil) could not be quantified. The same is the case for support measures and subsidies. For example, the VAT exemption for aviation and the gas production support policy are not included because no monetary estimate is available. And possible support for fossil fuel related activities as part of tax exemption programs for 'innovation' is excluded because it was found to be impossible to distinguish between different industries using the data available.

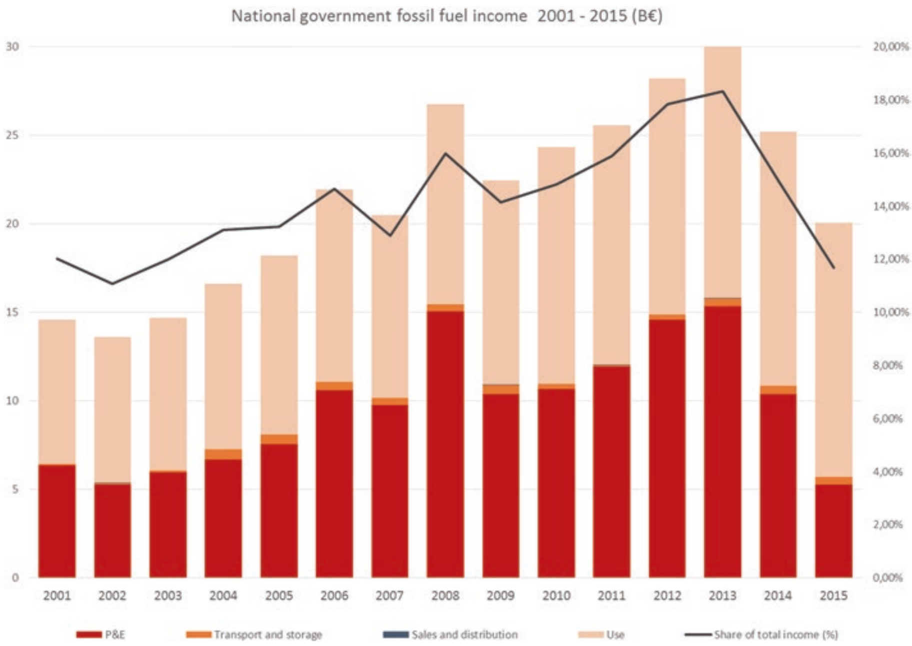

Fig. 6.3 Dutch government income from fossil fuels and related activities (2001–2015). (Source: Oxenaar, 2017)

Fig. 6.4 Government fossil fuel related expenditures (2001–2015). (Source: Oxenaar, 2017)

duction.[5] In 2015 this amounted to €4.36 billion, and between 2001 and 2015 on average €2.06 billion a year.[6] The lion's share of these subsidies went to excise tax exemptions for international marine shipping (€1.6 billion) and

[5] See the 'small field's policy' in later sections. No quantification of this measure is available.

[6] Another 2017 publication looking at support and subsidies from the Dutch government for fossil fuel related activities both within the Netherlands and abroad arrived at the even higher number of €7.6 billion annually (Van der Burg and Runkel, 2017).

aviation (€2.1 billion). The remainder went to income tax deductions for the marine sector (€237 million), energy tax restitutions (€133 million), a compensation subsidy for industries falling under the European Union, investment related tax deductions (€2.2 million), R&D subsidies (€17 million), and €106 million for oil storage (Oxenaar, 2017).

4.2 Exploration and Production

Since the first discovery of natural gas in 1959 the Netherlands has been a large producer with 3,582 billion cubic meters (bcm) having been extracted, and another 891 bcm in estimated proven reserves left.[7] The majority of which (665 bcm) is in the 'Groningen' field,[8] and the remainder in onshore (109 bcm) and offshore (117 bcm) 'small-fields' (TNO, 2016a). This position as a significant natural gas producer is currently shifting with production declining from 85.5 bcm in 2013 to 43.9 bcm in 2017 due to continually lowered production caps put in place on the Groningen field due to earthquakes (CBS, 2018b). Moreover, fields are maturing, with over 80% of the Netherlands' total reserves extracted (CBS, 2016a). This is also affecting gas exports, which declined by 40% over the same period (CBS, 2017) Production from the Groningen field is likely to be lowered further in an attempt to reduce seismic activity and related damages and deal with the social fallout related to these events.

Small amounts of oil, around 1,500 million kilo gram (kg) annually with a total reserve of 32 standard cubic meters (Sm3) (CBS, 2016b), and no coal is produced in the Netherlands. In 2015 the oil and gas reserves were valued at €103 billion, constituting around 14% of the government's total assets. On average between 2001 and 2015 the value was around €140 billion. Although naturally fluctuating based on the gas price the value of the reserves is now declining rapidly due to the lowered production rate, dropping to €42 billion in 2016, severely decreasing the government's wealth (Oxenaar, 2017).

Oil, gas, and mineral reserves are government property, but *de facto* ownership rights are transferred to license holders. In 2015, there were around 11 different gas field owners, 8 oil field owners, 13 operating permit holders, and 6 exploration permit holders. Of these the company *NAM*, a joint-venture between *Royal Dutch Shell (Shell)* and *Exxon Mobil*, is by far the largest permit and concession holder, with around 50% of all fields including the Groningen field. On behalf of the government, the SOE *EBN* takes a 40% financial stake

[7] For a complete production history of natural gas in the Netherlands see the graph on page 7 of TNO (2017).

[8] For a geographical overview of Dutch oil and gas production see the website: NLOG.NL.

in all developed fields except the Groningen field. *EBN* does not hold any production licenses but shares in the investments and revenue for each field and provides technical support. Although *EBN* is not directly involved in the Groningen field it does receive some of its profits through its holding in the gas wholesaler *GasTerra*. *EBN* also supports the exploration of oil and gas through its research efforts and knowledge sharing and is actively involved in finding end-of-life solutions and decommissioning of infrastructure. It thus actively supports oil and gas production from small-fields. Based on *EBN*s revenue of 4.76 billion in 2015 and its 40% share, a rough estimate of total revenue in the Dutch oil and gas production sector would amount to €10–12 billion for 2015 (Oxenaar, 2017).

In addition to the support provided through *EBN*, the government supports oil and gas production through its 'small-fields' policy and the related 'marginal fields and prospective incentive'. The small-fields policy was started in 1974 to maximise production from these fields and reduce withdrawals from the more flexible Groningen field. The policy entails an obligation for *GasTerra* to buy the gas, *Gasunie* to transport it, and *EBN* to take a 40% share. By taking away investment, transportation, and demand related risks it supports production. There is thus a clear dependency of producers on the involvement of these government parties. On the other hand, the government needs to create these conditions to extract its resources and realise the value of its reserves (Oxenaar, 2017). In-order to further incentivise offshore production producers can deduct 25% of their investment costs from their taxable profit and fallow areas can be 'de-licensed' reducing certain legal obligations for operators regarding liability. No monetary estimates of the magnitude of these support measures exist.

As a co-investor *EBN* is also involved in developing end-of-life solutions and decommissioning of oil and gas infrastructure. Given the low gas prices and maturing small (offshore) fields t is expected that decommissioning of infrastructure will become increasingly relevant. As such it is actively engaged in exploring possibilities to extend infrastructure lifetime, for example, through using 'green gas', carbon capture and storage (CCS), or wind-to-gas technologies to replace natural gas flows. Currently, *EBN* estimates that the government will contribute around 70% of decommissioning costs, amounting to €6.7 billion. Given that in 2014 alone total decommissioning costs amounted to €4.3 billion, *EBN* expects the total bill for the government could end up being considerably higher.

Since 2012 seismic activity around the Groningen field has become increasingly strong and has led to increased damage to buildings in the area. This leads to costs related to research on seismic activity, safety inspections, and payments for building retrofitting, reparations on damaged buildings, extra safety measures in new construction projects, and compensation payments. Although the operator of the Groningen field, *NAM*, is legally responsible for the safe operating of the field and thus liable for the damages caused by production the state plays an important role. It has taken up a role in implementing the above measures and pays for around 60% of the total costs, through both direct payments and reduced income from the Groningen field (Oxenaar, 2017).[9,10]

4.3 Transport and Storage

The Netherlands is a large importer of oil, coal, and gas, with coal and oil entering and leaving the country mainly through (sea) ports and gas through pipeline-interconnectors with Belgium, Germany, the United Kingdom, and Norway, and an LNG import terminal. The (sea) ports through which the fossil fuels enter the country are publicly owned and SOE *Gasunie* owns and operates the high-pressure gas network and co-owns the LNG import terminal. Coal transport and storage takes place in the publicly owned ports, but no government related entities are directly involved (Oxenaar, 2017).

4.4 Ports

The Netherlands has 17 publicly owned seaports of which the biggest are the Port of Rotterdam and the Port of Amsterdam. Both ports are 'fossil hubs' with over 50% of throughput, in tonnage, coming from oil, oil products, coal, and liquefied natural gas (LNG). They are also important for the Dutch economy: the port of Rotterdam's activities provides (indirectly) 3.3% of GDP.

The port of Rotterdam houses oil refineries, oil, coal, and LNG storage facilities, a coal fired power plant, and industry that uses oil and gas as an input. Together with the docking fees for ships bearing fossil loads, these activities provide a significant part of the ports revenues (Oxenaar, 2017).[11] Additionally, the intermediate products of the refineries are important inputs

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[9] See Follow The Money (n.d.).

[10] The agreements governing the extraction of the Groningen field are secret, this makes it impossible to determine what the exact distribution of responsibilities and costs between the involved parties *NAM, Shell, Exxon Mobil*, and EBN are.

[11] Unfortunately, the Port of Rotterdam does not breakdown its revenue in enough detail to determine the exact fossil share but given that over 50% of all throughput is fossil fuels, and many leaseholders are involved in fossil fuel related activities, they will provide an important share.

for the chemical industries and transport companies located in the surrounding areas (TNO, 2016b). Fossil fuels are thus not only important for the port itself but also for the region at large. For example, around 10,000 jobs, or 10% of port related employment, and €12.5 billion in added value are directly related to the oil refineries, chemical industry, and the coal fired power plant in the port.

In 2015, the port had a revenue of €657.3 million of which, based on fossil throughput, at least half of this could be related to fossil fuels. However, given the prominence of fossil fuel related activities in the port, and the revenue this generates through land leases, the fossil share of revenues probably lies above this 50%. The port authority pays annual dividends to its shareholders, the municipality of Rotterdam (70.8%) and the Dutch government (29.2%). Between 2004 and 2015 this amounted to, on average, €72 million annually. In 2015 this was €91 million of which €64.5 million for the municipality of Rotterdam, or 1.5% of the cities total budget. In addition, the share value of the port represents around 8% of the city's total assets and, in the past, the city has financially supported the port by providing a total of €1.16 billion in loans since 2004 (on which it received €383.4 million in interest). This totaled at least €50 million in operational subsidies and contributions from both the city and the national government, and €936 million in government contributions to investment, mainly for port expansions, between 2004 and 2015 (Oxenaar, 2017).

The city and national government are thus closely related to the port, both through ownership and financial flows, and there is a clear dependency of the port on government contributions to port expansions. Moreover, the port represents an unneglectable share of the city's assets (7.7%) and through dividend and interest payments contributes, in absolute terms, a significant amount to the budget (Oxenaar, 2017).

The second main seaport, the port of Amsterdam, has a strong focus on oil and oil products—it is the biggest gasoline port in the world—and the second largest coal port in Europe (after Rotterdam). In 2015, around 70% of its throughput was fossil fuels. On average, the port has paid around €41.5 million in annual dividends between 2005 and 2015 to its shareholder, the city of Amsterdam. This represents, on average over the same period, less than 1% of the cities total budget and around 1.8% of the cities freely spendable income. The capital value of the port represents 2.4% of the city's assets. In addition, the city has lent the port €147 million in 2013, on which it has received €18.6 million in interest since. Moreover, since 2013, a total of €3.3 million in subsidies given since could be identified, and €757 million in government (national, provincial, and municipal) contributions to port infrastructure investments. The relationship between the port and the city are thus strong, although, financially, the dependency is lower than in the Rotterdam case (Oxenaar, 2017).

Three other port entities, *Zeeland Seaports* ('ZSP'; 40% fossil), *Groningen Seaports* ('GSP'; estimated at least 26% fossil), and the *Port of Moerdijk* (5.6% fossil) were also analysed. These ports are less financially healthy, pay no or very limited dividends to their public owners, require guarantees or loans from their shareholders to continue operations, and their asset value presents a considerable share of their owner's total assets. It was found that all the analysed ports are dependent on their public owners in some respect, whether for infrastructure investments or loans and guarantees, and the public shareholders have a financial interest, based on dividend payments and/or asset value, in the ports (Oxenaar, 2017).

4.5 Gas Transport and Storage

The Netherlands has a large transport and distribution network for natural gas. The SOE *Gasunie* runs the high-pressure network while municipally owned regional distribution companies handle the low-pressure network. In 2015, *Gasunie* managed around 15,500 kilometre (km) of pipelines in the Netherlands and Germany and transported 1.179 Terawatt hours (Twh) of gas. Since 2007 the government, through *Gasunie*, has invested around €8.4 billion as part of its 'gas roundabout' policy in new international pipeline interconnectors, facilities for gas processing and storage, LNG import and breakbulk terminals, and a new trade platform for natural gas. *Gasunie* is also investing abroad, for example, it participated in the building of *Northstream one*,[12] in 2007 it bought part of the German transmission network for €2.1 billion, and it was looking to partake in *Northstream 2*. In addition, *Gasunie* expects to invest around €300–500 million annually to maintain the transmission network. In 2015, *Gasunie* paid €330 million in revenue to its sole shareholder, the Dutch government. Between 2002 and 2015 it contributed on average €313 million in dividends annually. Through *Gasunie* the government owns and manages practically all long-distance natural gas infrastructure in the country. *EBN*, the other SOE involved in oil and gas, also holds stakes (40%) in two large underground gas storage facilities and participates in several offshore trunk lines connecting some of its fields (Oxenaar, 2017).

[12] A natural gas pipeline running through the Baltic sea between Russia and Germany.

4.6 Oil Transport and Storage

Around 35% of all oil, oil products, and chemical products in the Netherlands are transported by pipeline. Currently seven different pipelines or pipeline networks are in operation in the country. The biggest of which is the NATO owned Central European Pipeline system (CEPS) that runs partly through the Netherlands. In the Netherlands it is operated by the *DPO*, falling under the ministry of defence. Through this system, the Dutch military provides at least around 50% (1.8 million cubic metres (mcm) minimum obliged purchase requirement) of the fuel needs for Amsterdam Schiphol airport, the main international airport of the Netherlands. DPO also provides commercial storage services. In this way the state is able to recuperate part of the maintenance costs for the CEPS network. Indirectly, through the government's 5.9% stake in the *KLM* airline, the government also partakes in the pipeline that supplies the other 50% of the fuel needs. All other oil pipelines in the Netherlands are privately owned.

The Netherlands has 30 mcm capacity of oil storage (2014), situated mainly in and around the ports and privately owned and operated. The government is involved in the storage of oil through its obligatory, as an EU and IEA member, strategic stockpiling of oil. The Netherlands Stockpiling Agency (COVA) maintains 80% of the stock (90 days of net import) stored in commercial storage terminals. This is financed through a stock levy on petroleum products, which totals to around €100 million a year in the past few years. Although *COVA* is a not-for-profit organisation it made around €19 million in profit in 2015. In addition to the tax revenue it receives, *COVA* has €953 million in loans guaranteed by the government. The government is thus directly involved in both the transport and storage of oil and natural gas (Oxenaar, 2017).

4.7 Processing and Refining

The Netherlands is a major producer of oil products with six refineries, five located in the port of Rotterdam and one in Flushing (Zeeland Seaports), supplying the North-West European market. In 2015 refinery output amounted to 60 Megaton (MT), almost 10% of OECD Europe, and 1.5% of global production. Although all refineries are privately owned, most by international oil companies (IOCs), they are all located in publicly owned ports, contributing to port income. It was however, impossible to determine the amount of revenue related to these leases. The refineries do benefit from an excise tax exemption on fuel used in the process, amounting to a loss of revenue for the government of around €40 million annually, last reported on in 2011. Some coal processing might take place in the storage facilities located in the ports. However, these are also privately owned and their share in port revenues unknown. For this reason, this was not further pursued in the analysis (Oxenaar, 2017).

The SOE *Gasunie* converts LNG, imported gas, and some domestically produced natural gas.[13] For example, in 2015 *Gasunie* converted 16.9 bcm of high calorific gas to low calorific gas by adding nitrogen to make it suitable for the Dutch grid. Given the lower production from the Groningen field, and the obligatory switching of large gas users to non-Groningen sources entering into force in 2022, gas conversion will increase in the coming years (Ministerie van Economische zaken en Klimaat, 2018).

4.8 Sales and Distribution

4.8.1 Oil

The sale and distribution of oil occurs through wholesalers and retailers or directly by the producer. In 2015, 1,152 petajoule (PJ) in fuels for road, rail, water, and air transport was supplied, of which 538 PJ through marine bunkers and 160 PJ through aviation bunkers found in the public ports and airports and 450 PJ for road transport and 7 PJ for rail transport. As mentioned earlier, international marine and aviation bunkering benefits from a tax exemption amounting to around €3.8 billion in 2015. The tax expense[14] for the government has grown considerably over the years from around €100–200 million per year in the early 2000s, to between 3 and 4 billion euros per year since 2011.

The government is involved in supplying fuels for road transport through the petrol stations leasing government owned land. Between 2002 and 2016 this brought in around €340 million, or €26.5 million on average per year. When it comes to oil, government involvement in this part of the chain is thus mainly financial, through income and tax exemptions (Oxenaar, 2017).

[13] Appliances in industry and households are adapted to the Groningen gas which is a low calorific gas (high in nitrogen), while gas from abroad or small-fields is high calorific gas (low in nitrogen) and needs to be made suitable for the Dutch grid by adding nitrogen.

[14] The ministry of finance does however note that the actual loss in taxes is likely to be lower, due to displacement of demand if the tax exemption were to be lowered or stopped.

4.8.2 Gas

GasTerra, a public-private partnership,[15] is the Dutch wholesaler for natural gas. It handles the gas imports from Russia and Norway, the gas coming from the Groningen field, around 85% of the small-fields production, and all gas exports. The company also serves a policy goal, being a key player in executing the governments 'small-field policy'. Being legally required to buy all gas extracted from the small-fields and taking a production driven approach to supply,[16] it takes over some of the production risk from the producers. This makes it easier for the producers to invest in small-field production. In addition to natural gas, *GasTerra* is also involved in developing a supply of, and demand for, biogas. For example, in 2015 *GasTerra* installed a high-pressure digester and concluded contracts to deliver 54 mcm of biogas. Although *GasTerra* has a very high revenue, €14.7 billion in 2015, its profits and dividends are capped at €36 million. Most of the added value runs through the 'Maatschap Groningen', a partnership between *NAM* and *EBN*, which pays taxes, royalties, and dividends to the government.[17] Through its policy activities, its political engagement, and lobbying through trade associations, *GasTerra* is also actively promoting natural gas in the Netherlands and Europe, pushing for more investments in production and infrastructure (Oxenaar, 2017).

Trade of natural gas in the Netherlands is facilitated by the Title Transfer Facility (TTF), a virtual gas trading hub for North-West Europe, in which *Gasunie* holds a 20% share. Since its foundation in 2003 it has grown considerably, becoming the largest trading facility for natural gas in Europe in 2016, with 21.468 TWh hour traded virtually and 516 TWh physically delivered.

Gasunie, as discussed previously, handles the high-pressure transport, while regional distributors, owned by municipalities, deliver to households. The larger distributors generate significant profits. In 2015 the regional distributors dividend a total of €527 million in dividends over hundreds of Dutch municipalities. Depending on the distributor, between 15 and 30% comes from activities related to natural gas. However, given the large number of

[15] *NAM* (50%; *NAM* is owned by *Shell* and *ExxonMobil*), *EBN* (40%), and the Dutch Ministry of Economic Affairs and Climate Change (10%) own *GasTerra*. Indirectly the government thus has 50% of the venture.

[16] *GasTerra* buys gas on the basis of availability instead of demand, provides flexible purchasing contracts but long-term buying guarantees. The goal of these measures was to increase producer profitability and maximise gas production from small fields.

[17] For an overview of the Dutch 'gas building', the complex structure of entities, ownership relations, and profit flows see figures 4 and 5 in van der Voort and Vanclay (2015).

shareholders, no municipality was found to have a large dependence on this revenue (Oxenaar, 2017).

4.8.3 Use

Final energy use in the Netherlands amounted to 2.586 PJ in 2015, with industry using 46%, transport 19%, households 17%, agriculture 5%, and other uses the remaining 13%. For industry around 625 PJ was used for energetic uses and 526 PJ for non-energetic uses, mainly as input for refining processes and the production of artificial fertilizer. The Dutch electricity mix is also largely fossil, with 42% coming from gas, 35% coal, and 4% 'other fossil fuels' and the remainder generated with nuclear, wind, solar, hydro, and biomass. The government is involved in the use of fossil fuels through its ownership of two utilities, through fiscal measures public airports, and its share in the airline *KLM*. Also, as discussed earlier, most refining activities take place in public ports (Oxenaar, 2017).

4.8.4 Electricity Production

Before the start of the liberalisation of the 'energy market', municipalities and provinces owned all utilities. *Eneco* and *PZEM* (formerly *DELTA*) are the final remnants of these and will likely be sold in the near future.[18] *PZEM*, with 22 shareholders of which the biggest is the province of Zeeland (50%), is currently in a bad financial position and most of its sellable activities have been sold. However, until 2015 it paid dividends to its shareholders, of which, on average between 2005 and 2015, around 57% coming from fossil fuel related activities. For the province of Zeeland this means it received €130 million in fossil dividends over that period. Prior to the start of *PZEM*'s financial issues in 2013, this made up between 10 and 15% of the provinces freely spendable income. The province has also stated explicitly that it remained a shareholder to protect regional employment, indicating that ownership also serves policy goals (Oxenaar, 2017).

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[18] A majority of its public shareholders have started talks to sell the utility *Eneco*, since it split off its grid management unit into a separate entity (owned by the *Eneco* shareholders) in 2017 the municipalities no longer deem ownership of the utility in the interest of the public. *DELTA* has had to undergo the same transformation, and due to its bad financial position had to sell many of its activities. However, since *DELTA* also partially owns the only nuclear power plant in the Netherlands, which is loss-making, and cannot be sold to foreign companies, it has not yet been possible to find a buyer.

Eneco, with 53 municipal shareholders including Rotterdam (31.7%) and The Hague (16.55%), is in a much better financial position and paid €103 million in dividends in 2015 of which around €77 million came from fossil fuel related activities. The municipality of Rotterdam received €25.5 million (1.5% of freely spendable income) and The Hague €12.8 million (1.6% of freely spendable income). As a share of the budget these 'fossil' dividends are thus only a minor part of these city's budgets. However, in absolute numbers it is still a significant financial contribution to the budget. Between 2005 and 2015 Rotterdam received in total €425.4 million and The Hague €222 million (Oxenaar, 2017).

The government also supports (renewable) electricity production through subsidies. Until 2006 subsidies were still given to gas fired power plants (combined heat and power: €320 million in total). Since then no direct subsidies have been given to fossil fuel powered plants. However, between 2003 and 2016, €3.42 billion in subsidies for biomass co-firing in coal plants has been given. In 2016 and 2017 possibilities to apply for further biomass co-firing subsidies were still open. Although this officially is a subsidy on renewable energy it has been argued that the subsidies have led to a postponement of old coal fired power plant decommissioning and could increase the profitability of currently uneconomic power plants (Oxenaar, 2017).

4.8.5 Government Participations in Fossil Fuel Use Related Companies

In addition to ports, almost all airports in the Netherlands are publicly owned. Although they do not use fossil fuels themselves, they facilitate the fossil fuel intensive aviation industry. Only the financial relations with the largest airport entity, *Schiphol Group*, owned by the national government (69.7%), Amsterdam (20.2%), and Rotterdam (2.2%) were analysed. In 2016 it transported around 70 million passengers and had a revenue of €1.4 billion, of which 70% related to aviation, resulting in a profit of €306 million. However, only around 18% of profit comes from activities directly related to aviation. Saying that, it can be argued that all other activities, such as retail and real estate, can only generate profit because of the aviation activities this makes it less clear what the share of fossil revenue is. Between 2001 and 2016 *Schiphol* paid out a total of €1.86 billion in dividends, of which €148 million was in 2016.

The national government is also a shareholder of the, formerly Dutch, airline *KLM* (5.9%) and the tiny *Winair* (8%). In both cases, the government keeps its share in the airlines to protect 'public interest' stating that *KLM* is crucial to the Dutch economy and *Winair* an essential transport provider. *KLM* pays only a very limited dividend, €1 million in total in 2015, and *Winair* is dependent on its public owners to stay afloat (Oxenaar, 2017).

4.8.6 Research and Development

The government supports R&D in different ways. On average, it funds 40% of all R&D in the Netherlands. In total, through a variety of direct subsidy measures and innovation support programs, €17 million in support for R&D related to fossil fuels was identified for 2015. This mainly went to projects on CCS, LNG, and 'tough gas' (i.e. offshore small field production). Between 2005 and 2015 at least €200 million in subsidies for fossil fuel related R&D was given. For all indirect subsidies, such as tax deductions for innovation, which amounted to €2.2 billion in 2015, it was impossible to determine the share going to fossil.

The government also funds R&D organisations and universities. For universities it was estimated that between €50 to a €100 million is spent on energy R&D annually. For the years 2009 and 2010 it was found that, respectively, €12.7 and €16 million was spent on fossil fuel related R&D. No recent data was found. For research organisations it is notable that one main government funded research organisation, TNO, focused its energy program entirely on natural gas and oil prior to 2008. However, it could not be determined how much was allocated on the projects in this program. Although a complete study of their R&D projects was not undertaken their natural gas related R&D was mainly on offshore gas production and exploration and LNG. This is relevant because it further underlines the governments support for offshore natural gas production (Oxenaar, 2017). It was also found that different, government related parties, such as universities, grid managers, and SOEs, form research consortia with research organisations and industry players. For example, in the Energy Delta Gas Research program, running between 2009 and 2015, which looks at the future of the energy system and the role of natural gas (Oxenaar, 2017).

5 Conclusion and Discussion

This chapter presented an overview of the main financial and ownership relations found between the Dutch government and the fossil fuel industry. On the one hand, it showed that fossil fuel related activities form an important source of revenue for the Dutch national government, amounting to, on average €21.5 billion a year, or 14% of freely spendable government income for the period 2001–2015. On the other hand, the government supports fossil fuel related activities with, on average between 2001 and 2015, €2.06 billion annually. The government was found to be tightly interwoven with the fossil fuel system, with ownership and financial relations found in all segments of the fossil fuel value chain, from production and exploration to use and R&D, and at the local, regional, as well as national levels of government. Moreover, through SOEs, it could be said the government itself is to some extent the fossil fuel industry, especially when it comes to the production, transport, storage, and distribution of natural gas. Finally, for the production of natural gas, the picture arises of a strong interdependency between government and industry, with the government providing a favourable framework for production, through subsidies, risk sharing, and (technical) support measures, and the industry generating revenue in the form of tax and royalties.

These findings support the hypothesis of a 'fossil fuel historical bloc'—an implicit 'alliance' between government and industry based on mutual dependencies—existing in the Netherlands. Moreover, the results seem to support the hypothesis that the existence of this bloc has contributed to the slow take-up of renewable energy despite decades of (apparent) policy support. As such it has contributed to the limited success of GHG-emission reduction policy in the Netherlands and provides some explanation of the pervasiveness of fossil fuels in the energy system. Given the need to steer away from fossil fuels to prevent dangerous climate change and preferably stay within a 1.5 degree pathway this supports the need for, and underlines the urgency of, a directed or managed decline of fossil fuels.

First, because the strength of the lock-in has, so far, prevented or drastically slowed a 'natural' decline or phase-out of fossil fuels. But also, because the active involvement of the government in the fossil fuel value chain, and related revenue streams, means that a decline in fossil fuels will have an impact on government assets and revenue. A managed decline would thus be necessary to speed up the required transition towards using mainly renewable energy sources and to prevent shocks to public finances.

Yet, in the frame of thinking about a 'managed decline' of fossil fuels this raises the question, who is supposed to 'manage' this decline? If it is the government, is it possible for a government to manage the 'decline' of an industry it itself is heavily involved in, and partly dependent upon? And, if so, what is needed for a government to start doing this?

Recent developments around natural gas production in the Netherlands provides an interesting case from which some lessons for the conditions under which a (government initiated) managed decline could occur. Increasing social unrest and related protests and civil society action in reaction to increasingly strong and prevalent earthquakes induced by natural gas production from the Groningen field[19] has led the Dutch government to adopt increasingly lower production caps for this field—42 bcm in 2014, 27 bcm for 2015, 24 bcm for 2016–2021, and 12 bcm for 2022, and 5–7.5 bcm for 2022 and beyond,—and in early 2018, the Minister of Economic Affairs outlined a plan to phase-out Groningen production by 2030 (Ministerie van Economische Zaken en Klimaat, 2017). This plan involves a large scale switch to alternative fuel/heating sources in industry, agriculture, and the built environment and would leave between 494 and 545 bcm of economically recoverable gas in the ground.[20] This is a radical break with previous policy, which was aimed at expanding or at least maintaining the role of natural gas in the Dutch energy system[21] and persisted despite the regular occurrence of earthquakes over the past decade, and impacts some of the relations and interdependencies described in this chapter. As a consequence of this decision production of natural gas in the Netherlands has decreased much more rapidly than it would have naturally (on the basis of fields maturing), dropping from 82 bcm in 2013 to 51 bcm in 2016, 43 bcm in 2017, and 27 bcm in the first nine months of 2018 (CBS, 2018b). Although production of both the many small fields and the large Groningen field was set to decline towards 2030 anyway due to declining production capacity and maturing small fields, a 2013 study by the producer *NAM* expected the Groningen field to be in production until 2080 (NAM, 2013: 17). Subsequently, government income from production has dropped from €15.4 billion in 2013 to €2.8 billion in 2016 and 2017[22] and the public and political discourse around natural gas has started to shift towards "getting rid of natural gas".[23] Although the phase-out plan has not yet been officially adopted, needs to be further developed, and might be vulnerable to damage claims from the Groningen concession holders (*ExxonMobil* and *Shell*),[24] this provides a clear example of how external pressure helped

[19] For an overview see: van Thienen-Visser and Breunesse. 2015. Induced seismicity of the Groningen gas field: history and recent developments.

[20] Own calculation based on current status of Groningen field and the phase-out pathways as currently set out by the national government (see: https://www.rijksoverheid.nl/actueel/nieuws/2018/03/29/kabinet-einde-aan-gaswinning-in-groningen).

[21] See for example the 'gas roundabout' policy and *EBN*'s involvement in preventing 'early' decommissioning of gas infrastructure as described in the study that underlies this chapter.

[22] A rise in the Dutch gas wholesale price compensated for the lower production.

[23] 'Van Gas Los' in Dutch.

[24] For now, both Shell and Exxon have made a deal with the Dutch government, relinquishing any future damage claims in exchange for a higher percentage of current profits from the Groningen field (27% versus 10% previously).

'opening' up the regime and the 'fossil fuel historical bloc' and pushed the government towards beginning a 'managed decline' in natural gas production.

This recent development shows that, despite extensive government-fossil fuel industry ties, strong and lasting external pressure can move the system towards initiating a decline of fossil fuels.[25] It does however raise questions regarding whether this 'crisis' response in the face of earthquakes can be seen as a 'managed' decline and thus prevent impacts on public finances and jobs. See, for example, the rapid and unplanned-for reduction in government revenues from natural gas. And, thus, if external pressure is an influential factor in pushing the regime towards the breakdown and phase-out phases of transition, to what extent is a 'managed'- meaning guided and directed—decline possible?

From these conclusions we can draw several insights for the discussion on a managed decline of fossil fuels. First of all, that strong government-fossil fuel industry interdependencies can hamper and/or slow the phase-out of fossil fuels and thus the transition towards a low-carbon energy system. This indicates that the government should start breaking down such relations throughout the fossil fuel value chain and at all government levels. However, at the same time, it should see if it can use some of the existing ties as 'levers' in accelerating the shift away from fossil fuels. What if, for example, the Dutch government started using its SOEs to invest in renewable energy? *EBN* has state-of-the-art knowledge of the Dutch subsoil based on decades of oil and gas exploration and well-drilling. This is knowledge that is also highly relevant in further developing geothermal energy. Moreover, its involvement, for example, by co-investing in production as it does in oil and gas, could reduce (financial) risks. The government could start taking a more pro-active role as a shareholder and start using its SOEs as a policy lever in the energy transition. This would however require a shift in the government's view on dealing with SOEs. Although the government holds shares in these companies to secure the public good and officially strives towards being an 'active shareholder' (Rekenkamer, 2015), the current attitude towards SOEs seems to be to see them as independent entities that the government should not or cannot control directly. Yet, *GasTerra*, and *Gasunie* are also used to enact the 'small-fields policy' to maximise gas production from small-fields and *EBN* to support offshore production.

[25] The discussion around production has also led to measures aimed at reducing gas use. For example, new houses in the Netherlands are no longer obliged to be connected to the gas grid, enforcement of existing energy efficiency laws for companies has been increased, and large users of natural gas have been requested to start switching to alternative sources of gas/energy.

Secondly, when thinking about managing the decline of fossil fuels, government fossil fuel related income and spending should be taken into account. On the one hand, because their existence can hinder or slow a decline, on the other hand, because a decline could have an impact on public finances and economic stability. If strong financial relations and/or dependencies exist it might be prudential to plan-ahead instead of waiting for a shock, such as the earthquake related fallout in the Netherlands, to occur. This also means looking at how to ensure future public revenue from the energy system. For example, in addition to using SOEs to accelerate the transition towards a renewable energy-based system, they could at the same time also serve to ensure future public revenue. If oil and gas were seen as resources that should provide benefits to society as a whole, in the form of royalties and taxes, why should the same not be the case for renewable sources of energy? Especially at a time when gas production and related revenues are decreasing rapidly, damage payments will need to be made, and (offshore) wind is becoming cost competitive: this could be fruitful in the Netherlands.[26]

Finally, from a transitions perspective, a managed decline involves a multitude of actors, especially citizen initiatives and NGOs, and requires strong external pressure by these actors on the system. The multi-actor aspect of transitions and the possibility of a 'fossil fuel historical bloc' means that it is not enough to just look at the government when thinking about managing the decline of fossil fuels. Other regime parties, such as SEOs involved in the energy system, and external pressure in the form of crises have the potential to accelerate the decline of fossil fuels. Especially, there is a role for collective action, citizen initiatives and pressure groups, and NGOs such as, for example, the global divestment movement, activist shareholders demanding more insight in climate related risks, and citizens demanding change in leveraging crises and building external pressure should not be underestimated. In the Dutch case these have shown to be crucial in 'opening' up the regime and providing space within and for the government to start steering towards a decline of fossil fuels.

References

Avelino, F. and Wittmayer, J.M. 2016. Shifting Power Relations in Sustainability Transitions: A Multi-actor Perspective. *Journal of Environmental Policy & Planning* 18: 628–649. https://doi.org/10.1080/1523908X.2015.1112259

[26] The first 'subsidy free' offshore wind park will, if all goes well, be built in the Netherlands in 2022.

Bosman, R., Loorbach, D., Frantzeskaki, N. and Pistorius, T. 2014. Discursive Regime Dynamics in the Dutch Energy Transition. *Environmental Innovation and Societal Transitions* 13: 45–59. https://doi.org/10.1016/j.eist.2014.07.003.

CBS. 2016a. Aardgas voor bijna 80 procent op [WWW Document]. https://www.cbs.nl/nl-nl/nieuws/2016/37/aardgas-voor-bijna-80-procent-op.

CBS. 2016b. CBS StatLine—Aardoliegrondstoffenbalans; aanbod, verbruik en voorraad [WWW Document]. http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=83325ned&D1=1-2,9-10&D2=1,l&D3=0&D4=0-68,85,102,111,119,122,124-126,l&HDR=G1,G2,G3&STB=T&VW=T.

CBS. 2017. Aardgasexport in drie jaar gehalveerd [WWW Document]. http://www.cbs.nl/nl-nl/nieuws/2017/09/aardgasexport-in-drie-jaar-gehalveerd.

CBS. 2018a. CBS StatLine—Overheid; inkomsten en uitgaven 1995–2017 [WWW Document]. http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82563NED&D1=0,73-76&D2=1&D3=13,18,23,28,33,38,43,48,53,58,63,68,73,78,83,88,93,l&HDR=G1,G2&STB=T&VW=T.

CBS. 2018b. CBS StatLine—Aardgasbalans—aanbod en verbruik [WWW Document]. http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=00372.

Climate Action Tracker. 2017. Temperatures | Climate Action Tracker [WWW Document]. https://climateactiontracker.org/global/temperatures/.

Correljé, A. and Verbong, G. 2004. The Transition from Coal to Gas: Radical Change of the Dutch Gas System. In: Elzen, B., Geels, F.W. and Greem, K. (Eds.) *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*. Cheltenham: Edward Elgar, pp. 114–134.

Eurostat. 2017. Renewable Energy in the EU. http://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics.

Follow the Money. (n.d.). Home. https://www.ftm.nl/artikelen/gasgebouw-onder-druk.

Geels, F.W. 2011. The Multi-level Perspective on Sustainability Transitions: Responses to Seven Criticisms. *Environmental Innovation and Societal Transitions* 1: 24–40. https://doi.org/10.1016/j.eist.2011.02.002.

Geels, F.W. 2014. Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society* 31: 21–40. https://doi.org/10.1177/0263276414531627

IEA. 2014. *The Netherlands 2014 Review, Energy Policies of IEA Countries*. International Energy Agency (IEA).

IPCC. 2014. Climate Change 2014, Mitigation of Climate Change.

Jakob, M. and Hilaire, J. 2015. Climate Science: Unburnable Fossil-Fuel Reserves. *Nature* 517: 150–152. https://doi.org/10.1038/517150a.

Karltorp, K. and Sandén, B.A. 2012. Explaining Regime Destabilisation in the Pulp and Paper Industry. *Environmental Innovation and Societal Transitions* 2: 66–81. https://doi.org/10.1016/j.eist.2011.12.001.

Kern, F. and Smith, A. 2008. Restructuring Energy Systems for Sustainability? Energy Transition Policy in the Netherlands. *Energy Policy* 36: 4093–4103. https://doi.org/10.1016/j.enpol.2008.06.018.

Levy, D.L. and Newell, P.J. 2002. Business Strategy and International Environmental Governance: Toward a Neo-Gramscian Synthesis. *Global Environmental Politics* 2: 84–101.

Loorbach, D. 2009. Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance* 23: 161183. https://doi.org/10.1111/j.1468-0491.2009.01471.x.

Loorbach, D., Frantzeskaki, N. and Avelino, F. 2017. Sustainability Transitions Research: Transforming Science and Practice for Societal Change. *Annual Review of Environment and Resources* 42: 599–626.

McGlade, C. and Ekins, P. 2015. The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2°C. *Nature* 517: 187–190. https://doi.org/10.1038/nature14016.

Meadowcroft, J. 2009. What About the Politics? Sustainable Development, Transition Management, and Long Term Energy Transitions. *Policy Sciences* 42: 323–340. https://doi.org/10.1007/s11077-009-9097-z.

Ministerie van Economische Zaken en Klimaat. 2017. Minder gaswinning Groningen—Gaswinning in Groningen—Rijksoverheid.nl. https://www.rijksoverheid.nl/onderwerpen/gaswinning-in-groningen/minder-gaswinning-groningen.

Ministerie van Economische Zaken en Klimaat. 2018. Instemmingsbesluit Groningen gasveld 2018–2019. Rijksoverheid.nl. https://www.rvo.nl/sites/default/files/2018/11/Instemmingsbesluit_Groningen_gasveld_2018-2019.pdf.

Moncrieffe, J. and Luttrell, C. 2005. *An Analytical Framework for Understanding the Political Economy of Sectors and Policy Arenas*. London: ODI.

NAM. 2013. Winningsplan Groningen 2013. https://nam-feitenencijfers.data-app.nl/download/rapport/6c47c8fe-1ba3-43f1-85b1-f783f48e4e45?open=true.

Oxenaar, S. 2017. Mapping the Financial and Organizational Interdependencies Between the Dutch State and the Fossil Fuel Industry. Master Thesis, Humboldt University Berlin and DRIFT, Erasmus University Rotterdam.

Paris Agreement to the United Nations Framework Convention on Climate Change. December 12, 2015. Chapter XXVII, 7. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

Phelan, L., Henderson-Sellers, A. and Taplin, R. 2013. The Political Economy of Addressing the Climate Crisis in the Earth System: Undermining Perverse Resilience. *New Political Economy* 18: 198–226. https://doi.org/10.1080/13563467.2012.678820.

Rekenkamer, A. 2015. De Staat als aandeelhouder. https://www.rekenkamer.nl/publicaties/rapporten/2015/04/07/de-staat-als-aandeelhouder.

Rijksoverheid. 2018a. Nuon krijgt vergunning voor windpark zonder subsidie, March 19, 2018. https://www.rijksoverheid.nl/onderwerpen/duurzame-energie/nieuws/2018/03/19/nuon-krijgt-vergunning-voor-windpark-zonder-subsidie.

Rijksoverheid. 2018b. Kabinet: einde aan gaswinning in Groningen. https://www.rijksoverheid.nl/actueel/nieuws/2018/03/29/kabinet-einde-aan-gaswinning-in-groningen.

Rotmans, J., Kemp, R. and Van Asselt, M. 2001. More Evolution Than Revolution: Transition Management in Public Policy. *Foresight* 3: 15–31.

Schoots, K. Hekkenberg, M. and Hammingh, P. 2017. Nationale Energieverkenning 2017 (No. ECN-O--17-018). Energieonderzoek Centrum Nederland, Petten.

Smink, M.M. 2015. Incumbents and Institutions in Sustainability Transitions. Doctoral Thesis, Utrecht University, The Netherlands.

TNO. 2016a. Delfstoffen en aardwarmte in Nederland: Jaarverslag 2015.

TNO. 2016b. Het fossiele dilemma van Rotterdam, TNO Discussiepaper. TNO.

TNO. 2017. Van importeur naar exporteur: de veranderende rol van aardgas in Nederland. http://bit.ly/2wewT3t.

Turnheim, B. and Geels, F.W. 2012. Regime Destabilisation as the Flipside of Energy Transitions: Lessons from the History of the British Coal Industry (1913–1997). *Energy Policy* 50: 35–49. https://doi.org/10.1016/j.enpol.2012.04.060.

Turnheim, B. and Geels, F.W. 2013. The Destabilisation of Existing Regimes: Confronting a Multi-dimensional Framework with a Case Study of the British Coal Industry (1913–1967). *Research Policy* (Economics, Innovation and History: Perspectives in Honour of Nick von Tunzelmann) 42: 1749–1767. https://doi.org/10.1016/j.respol.2013.04.009.

Unruh, G.C. 2000. Understanding Carbon Lock-in. *Energy Policy* 28: 817–830. https://doi.org/10.1016/S0301-4215(00)00070-7.

Van den Bergh, J.C.J.M. 2013. Policies to Enhance Economic Feasibility of a Sustainable Energy Transition. *Proceedings of the National Academy of Sciences of the United States of America* 110: 2436–2437. https://doi.org/10.1073/pnas.1221894110.

Van der Burg, L. and Runkel, M. 2017. Phase-Out 2020: Monitoring Europe's Fossil Fuel Subsidies. Briefing Paper, ODI, London.

Van der Loo, F. and Loorbach, D. 2012. The Dutch Energy Transition Project (2000–2009). In: *Governing the Energy Transition: Reality Illusion Necessity*. New York: Routledge.

Van der Voort, N. and Vanclay, F. 2015. Social Impacts of Earthquakes Caused by Gas Extraction in the Province of Groningen, The Netherlands. *Environmental Impact Assessment Review* 50, 1–15. https://doi.org/10.1016/j.eiar.2014.08.008.

Van Raak. 2015. Transition Policies: Connecting System Dynamics, Governance, and Instruments, in an Application to Dutch Healthcare. Doctoral Dissertation, Erasmus University, Rotterdam, The Netherlands.

Van Vuuren, D., Hof, A., Gernaat, D. and de Boer, H.S. 2017. *Limiting Global Temperature Change to 1.5°C: Implications for Carbon Budgets, Emission Pathways,* *and Energy Transitions* (No. 2743). PBL Netherlands Assessment Agency. https://www.pbl.nl/en/publications/limiting-global-temperature-change-to-1-5-degree-celsius.

Verbong, G. and Geels, F. 2007. The Ongoing Energy Transition: Lessons from a Socio-technical, Multi-level Analysis of the Dutch Electricity System (1960–2004). *Energy Policy* 35: 1025–1037. https://doi.org/10.1016/j.enpol.2006.02.010.

Verbong, G. and Loorbach, D. (Eds.). 2012. *Governing the Energy Transition: Reality, Illusion or Necessity?* Routledge Studies in Sustainability Transitions. New York: Routledge.

Weterings, R., van Harmelen, T., Gjaltema, J., Jongeneel, S., Manshanden, W., Poliakov, E., Faaij, A., van den Broek, M., Dengerink, J., Londo, M. and Schoots, K. 2013. Naar een toekomstbestendig energiesysteem voor Nederland (No. TNO 2013 R10325). TNO Reports.

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Fossil Fuels and Transitions: The UK Maximising Economic Recovery Strategy and Low-Carbon Energy Transitions

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1 Introduction

The current policy of the United Kingdom (UK) Government in relation to the oil and gas industry is to maximise economic recovery from the UK continental shelf (UKCS). Simply named, the Maximising Economic Recovery (MER) Strategy published by the Oil and Gas Authority (OGA) in 2016, pursuant to the Petroleum Act 1998 and the Infrastructure Act 2015 (Oil and Gas Authority, 2016) has the principal objective of recovering as much UK petroleum as economically possible. The MER Strategy was the result of a review of the UKCS commissioned by the UK Government and undertaken by Sir Ian Wood, who published an interim report in 2013 and a final report in 2014 (The Wood Review) (Wood, 2014). It is worth highlighting that Sir Ian Wood's background is in oil and gas investment in the North Sea (Forbes, 2019), and that he founded the Wood Group, a global company offering engineering, project and technical services in the industrial and energy sectors (Wood Group, 2019).

The Wood Review noted that over time, production in the UKCS had fallen due to a variety of factors, including a fall in production efficiency and

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a sharp decline in exploration. The MER Strategy calls for collaboration among UKCS licensees to attain the principal objective. According to the Wood Review, if the MER Strategy was implemented fully, an estimated 3–4 billion barrels of oil equivalent (bboe), more than would otherwise be recovered over the next 20 years (by 2035) under business-as-usual, could be recovered. Translated into financial (economic) terms, this could contribute over GB£200 billion to the UK economy.

One would not be amiss, however, in asking why the UK would be seeking to maximise economic recovery of its petroleum in the face of the global energy transition from fossil fuels to renewable and low carbon energy. The UK is a contracting party of the Paris Agreement on Climate Change, 2015, came into force in December 2016, upon ratification by the 55th party. To date, 185 countries (out of 197) have ratified the Paris Agreement (United Nations Framework Convention on Climate Change (UNFCCC), 2018).

The Paris Agreement seeks to hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. As a member of the European Union (EU), the UK has committed to the EU Nationally Determined Contribution (NDC) to achieve a 40% reduction in greenhouse gas (GHG) emissions by 2030, compared to 1990 as the base year for comparison (UNFCCC, 2016). Domestically, the UK, under the Climate Change Act 2008, aims for a net UK carbon account for the year 2050 that is least 80% lower than the 1990 baseline. These commitments will require a significant reduction in the use of fossil fuels and the adoption of other stringent measures to cut emissions.

The question then arises as to whether the MER Strategy fits into the UK's and the on-going global energy transition, and in particular, climate change goals established under the Paris Agreement and the UK Climate Change Act 2008. This paper analyses the MER Strategy in light of the global energy transition and seeks to answer this question.

Section 2 of this chapter will provide background to the reasons behind the MER Strategy by discussing the contribution of the UKCS to the UK economy and energy security, and its rise and fall. Section 3 will discuss the UK MER strategy in detail, including the findings of the Wood Review of 2014, the policy provisions of the MER Strategy, and the MER Strategy in practice. Section 4 will discuss the global energy transition and the UK ambitions and obligations under the Paris Agreement. It will also discuss the UK's national obligations under the Climate Change Act 2008, and government policies over the years that have called for a low-carbon transition. In addition, this section will discuss the impact of Brexit on UK energy transition goals. Section

5 will analyse the MER Strategy in light of the UK's energy transition goals and climate change obligations and seek to answer the question of whether the MER Strategy can go hand in hand with the UK's and the global energy transition. Section 6 will provide a conclusion to this chapter and suggest a way forward for the MER strategy in a world of climate change obligations and energy transition goals.

2 The Rise and Fall of the UKCS

The UKCS comprises of the sea bed and subsoil beyond the UK's territorial sea over which the UK exercises sovereign rights of exploration and exploitation of natural resources (Eisourcebook.org, 2015). The UKCS includes parts of the North Sea, the North Atlantic, the Irish Sea and the English Channel and is bordered by Norway, Denmark, Germany, the Netherlands, Belgium, France and the Republic of Ireland, with a median line setting out the domains of each of these nations as was established by mutual agreement between them (Legislation.gov.uk, 1964).

After the passage of the Continental Shelf Act in 1964, the UK began development of its offshore oil reserves. The UK was a net importer of energy in the 1970s and became a net exporter of energy in 1981 after developments in the UKCS. Production peaked in 1999, and in 2004, the UK stopped being a net exporter of energy, and became a net importer: this has been the position to date (Department for Business, Energy and Industrial Strategy (BEIS), 2018).

The oil and gas industry in the UK has suffered significant setbacks since the oil price started to fall from 2014. According to a 2018 UK House of Commons Report titled, '*Future of the UK Oil & Gas Industry*' (UK House of Commons Library, 2018):

(a) as of 2018, the UK oil & gas industry (offshore and onshore) directly employed 37,000 people, and 127,000 indirectly in relevant supply chains. These numbers were a fall of 30% since 2013;
(b) in 2017/2018, government tax revenues from the oil & gas sector (corporation tax and petroleum revenue tax) were GB£1.2 billion, which was substantially lower than the sector's revenues in the 2008/2009 peak period (GB£12.4 billion);
(c) in 2017, capital investment in the oil & gas sector was GB£5.6 billion, compared to GB£15 billion in 2014;

(d) in 2017, 94 wells (71 development, 14 exploration and 9 appraisal) were drilled on the UKCS, the fewest since 1973; and
(e) the cost of decommissioning was GB£1.8 billion in 2017, a 48% increase from 2016.

According to the UK House of Commons Report 2018, the Office for Budget Responsibility's January 2017 Fiscal sustainability report, predicted a "long-run decline" in production from the UKCS (UK House of Commons Library, 2018: 7). It should be borne in mind that, as noted in the Wood Review production in the UKCS had fallen over the years principally due to a fall in production efficiency and a sharp decline in exploration. The fall in UKCS production is therefore not attributable to the UK's climate change goals and obligations.

In 2016, the Financial Times observed that numerous oil & gas assets in the UKCS were for sale with many of the major oil and gas companies having plans to reduce their activity, and some planning their complete exit where buyers can be found. Smaller operators had closed down due to unmanageable debts. More than 120 fields had ceased production by 2016, and stood idle without being formally abandoned, since the oil companies and the government were reluctant to spend the large sums involved in the abandonment activity (Butler, 2016).

According to OilPrice.com, since peaking at 2.6 million barrels per day (bpd) in 1999, UKCS production had been in decline until 2015, when it started stabilising. This was largely thanks to start-ups and improved production from existing fields with infill drilling. These start-ups include BP's Quad 204 project in the west of Shetland region and EnQuest's Kraken development. Production in 2016 and 2017 was at an estimated 1.63 million boepd. The decline is projected to resume in 2019 (OilPrice.com, 2018).

In its '*World Economic Outlook*' for 2017, the International Energy Agency (IEA) noted that though crude price has increased since late 2016, following interventions by OPEC members to support the market, investment is not sufficient to avoid the looming decline. The IEA noted that North Sea oil production was expected to rise to 1.1 million barrels daily in 2018–2019. It is then forecasted to drop by around 20% to 0.9 million bpd by 2023. (IEA, 2017).

Oil and gas has provided the majority of the world's primary energy needs since the mid-1960s, with industries such as transport being almost totally reliant on petroleum-based products. Even with the entry and expansion of the use of renewable energy sources and new and better technologies which influence storage, the reliance of the global energy system on oil and gas remains significant. This is largely because of the following reasons:

1. Continued worldwide population and economic growth, a large part of which is expected in Africa and Asia. This will lead to increasing disposable incomes and living standards. It is projected that global energy demand is expected to grow by 30% by 2040;
2. Switching from coal to gas to reduce carbon intensity. According to the IEA, in China, which is heavily reliant on coal for energy, coal use peaked in 2013 and is set to decline by almost 15% over the period to 2040. Natural gas is projected to be the 2nd largest fuel in the global mix after oil by 2040 (IEA, 2017); and
3. There are many sources of energy demand where emerging technologies and methods of supply which, though promising, do not yet provide an effective alternative to the use of oil or gas.

This reliance on oil and gas also applies to the UK. In 2017, oil and gas accounted for 72% of the UK's total primary energy (UK House of Commons Library, 2018). It is on the basis of assuring the UK's energy security that the UK government commissioned the 2014 Wood Review and adopted the MER Strategy. The next section discusses the MER Strategy.

3 The UK Maximum Economic Recovery (MER) Strategy

3.1 Introduction to the MER Strategy

The UK MER Strategy was published by the OGA in 2016 and sets out several strategies for maximising economic recovery of oil & gas from the UKCS (Oil and Gas Authority, 2016). As previously mentioned, the policy of the UK Government in relation to the oil and gas industry is to maximise economic recovery from the UKCS, and it is for this reason that the UK Government commissioned the 2014 Wood Review by Scottish oil magnate, Sir. Ian Wood. It should be noted that the Wood Review and the UK MER Strategy are primarily focused on maximising economic recovery of the UKCS, and do not appear to take into account factors such as climate change and the UK policies on the energy transition.

At the time of preparation of the Wood Review, the UK Government body charged with overseeing oil and gas activities in the UKCS was the Department of Energy and Climate Change (DECC) (now the Department for Business, Energy and Industrial Strategy or BEIS). DECC was noted to be understaffed in light of its responsibilities.

Under Section 9 A (2) of the Petroleum Act 1998 (as amended by the Infrastructure Act 2015), UKCS MER would be achieved principally through: (a) development, construction, deployment and use of equipment used in the petroleum industry (including upstream petroleum infrastructure); and (b) collaboration among holders and operators of petroleum licences, owners of upstream petroleum infrastructure, and persons planning and carrying out the commissioning of upstream petroleum infrastructure. (Legislation.gov.uk, 1998).

The Wood Review noted that the UKCS production and landscape had changed over time. It has a mix of frontier areas, assets over 30 years old or approaching the end of their life, and new plays. It was noted that although investments in the UKCS had reached a high of GB£14 billion in 2013, production had fallen by 38% between 2010 and 2013 (a production deficit of 500 million boe) due to a variety of factors including a fall in production efficiency and a sharp decline in exploration. According to the Wood Review, if the MER Strategy was implemented fully, an estimated 3–4 billion barrels of oil equivalent more than would otherwise be recovered over the next 20 years (by 2035) could be recovered, translating to a contribution of over GB£200 billion to the UK economy.

In its response to the Wood Review, the UK government noted the MER Strategy was in line with achieving the objectives under the Carbon Plan 2011, which shows that the UK will still need significant oil and gas supplies over the next decades while it pursues decarbonisation efforts and transitions to a low carbon economy (DECC, 2014).

The Wood Review noted that the UK's 'light touch' regulatory model which applied in the early days of large fields and large operators needed to change. The model needed to adapt to a landscape with over 300 fields operated by both large and small operators, and in which greater interdependence was required to exploit marginal fields and smaller discoveries. The Wood Review made the following four (4) recommendations in order to achieve UKCS MER (Wood, 2014):

1. The UK Government and industry should adopt a tripartite approach, and commit to a new strategy to achieve MER in the UKCS;
2. Creation of a new regulator, independent of DECC (now BEIS), charged with stewardship and regulation of the UKCS, and maximising collaboration in exploration, development and production;

3. Granting of additional powers to the new regulator to ensure that among others: licences operate according to MER UK; there is an effective dispute resolution mechanism that includes mediation and expert assessors; there is a system of formal and informal warnings to operators which could lead to the loss of operatorship and licences in the case of non-compliance; and the regulator is able to attend consortium and management committee meetings of operators; and there is transparent and timely data to enhance competition; and
4. Developing and implementing sector strategies to achieve MER, with the six principal strategies being: exploration (including data access); asset stewardship (including production efficiency); regional development; infrastructure; technology (including enhanced oil recovery and carbon capture and storage (CCS)); and decommissioning.

Recommendation 2 on a new regulator led to the establishment of the OGA which became an Executive Agency independent of DECC in 2015 and a government company under the Companies Act in 2016.

In May 2016, at the Scottish Energy Jobs Task Force, the OGA, Oil & Gas UK (an industry representative organisation) and stakeholders mapped out '*Vision 2035*', the UK oil and gas industry's long-term vision for the sector (UK Oil and Gas Industry, 2016). The purpose of Vision 2035 is to: provide direction and instil confidence; inspire transformation and drive collaboration; create competitive advantage; and secure investment and drive value.

The MER Strategy is now geared towards achieving Vision 2035. There are four main dimensions to Vision 2035: People—attracting a talented workforce by securing investment in the industry and enabling transition to different parts of the energy sector; Energy security—maximising economic recovery from the UKCS; Technology—leading technology in mature basin solutions; and Exports—maintaining a leading global position in sub-sea engineering and sustaining the oil and gas sector long after the final economic reserves have been produced.

3.2 Components of the MER Strategy

The MER Strategy has four (4) main components: the Central Obligation; the Supporting Obligations; the Required Actions and Behaviours; and the Safeguards (Oil and Gas Authority, 2016). Table 7.1 below discusses the 4 main components.

The MER Strategy further provides that in instances where relevant persons (licensees) decide not to ensure MER, the relevant persons must allow other persons who are more financially or technically competent to seek MER from the relevant licences or infrastructure by all appropriate means. This may include licensees seeking investment from other persons, or divesting themselves of such licences or assets (Oil and Gas Authority, 2016: 13).

Table 7.1 The four components of the UK MER strategy

Strategy component	Description
Central obligation	This is a high-level obligation of general application which requires relevant persons to take the steps necessary to secure the maximum value of economically recoverable petroleum from UK waters. There is a legal obligation under the Petroleum Act 1998 to comply with the MER Strategy.
Supporting obligations	These broadly set out how the Central Obligation applies in specific circumstances under the areas of Exploration, Development, Asset stewardship, Technology and Decommissioning: (a) Exploration—licence holders are required to undertake exploration activities within their licence area in an optimal manner for maximising the value of economically recoverable petroleum from that area. A licence holder cannot relinquish a licence without having completed the work programme previously agreed upon; (b) Development—any infrastructure is required to be optimally planned and configured to maximise the value of economic recoverable petroleum from the region it is located; (c) Asset stewardship—owners and operators of infrastructure must ensure that its operation and maintenance is such that it achieves optimum levels of performance, including production and cost efficiency. This includes licencees allowing access to infrastructure on fair and reasonable terms; (d) Technology—relevant persons must ensure that technology is deployed to optimum effect and in accordance with plans produced by the OGA; and (e) Decommissioning—before decommissioning of infrastructure, opportunities for the continued use of the infrastructure must be considered and implemented in a cost-effective way for maximum recovery of petroleum.
Required actions & behaviours	Create obligations to collaborate with others in the execution of the MER Strategy. Any obligations under either the Central Obligation or the Supporting Obligations must be executed within the parameters below: (a) Timing—all obligations must be complied within a timely fashion; (b) Collaborative effort—relevant persons must consider whether collaboration or co-operation could reduce costs and increase economic recovery of petroleum. Relevant persons are also obligated to cooperate with the OGA; and (c) cost reduction—this must be implemented throughout the petroleum lifecycle, including in decommissioning.

(*continued*)

Table 7.1 (continued)

Strategy component	Description
Safeguards	The Safeguards (which the central and supporting obligations as well as the required actions and behaviours are subject too) are: (a) No conduct can be required under the MER Strategy which would be prohibited under any legislation, including legislation on competition, health, safety and environmental protection. Further, no conduct can be required which would be prohibited under common law (including the OGA's common law obligation to act reasonably); (b) No person can be required to invest or fund activity where they will not make a satisfactory expected commercial return from it. Further, any delay or decision by a relevant person to refrain from investment or activity can only be on the grounds that it will not receive a satisfactory commercial return; (c) Where a relevant person is required to invest or fund an activity that will benefit a third party, that relevant person can require a fair and reasonable financial contribution from the third party in an amount which is fair and reasonable; (d) The assessment of what is fair and reasonable must consider all the circumstances and, specifically, the importance of realising the third party's assets to meet the over-arching central obligation; and (e) In order for there to be a balance between the benefit to the UK and investor confidence, no investment, funding or other conduct will be required where the benefits of it to the UK are outweighed by the potential damage to investor confidence in exploration/production projects offshore UK that imposing the requirement will cause.

Note: Information derived from the UK Oil and Gas Authority (2016)

Where licensees allow other financially and technically competent persons to pursue MER over their assets, the divesting licensees should not demand compensation in excess of a fair market value or demand unreasonable terms and conditions from the other persons. If after a reasonable period the relevant person is unable to secure alternative funding or to divest themselves of the asset then, they would be required to relinquish the related licenses.

3.3 The MER Strategy in Practice

As discussed, the MER Strategy is a collaboration between the UK government and the industry, with the OGA as the regulatory body in charge of its successful implementation. Aside from the regulator-licensee relationship, industry stakeholders are involved through participation in the MER UK Forum, MER UK Steering Group and six MER UK Taskforces (Oil and Gas Authority, 2019). As such, there appears to be strong industry participation.

The six MER UK Taskforces are the first tier of collaboration between government and industry and pertain to the areas of: (1) Asset stewardship; (2) Decommissioning; (3) Efficiency; (4) Exploration; (5) Supply chain and exports; and (6) Technology leadership.

Each taskforce has industry members from companies and Oil & Gas UK. Each taskforce is also led by an industry representative, with an OGA support lead. For instance, the Asset Stewardship Taskforce is presently led by a representative from Apache, and members comprise of representatives from Total, BP, NSMP, Doosan Babcock, EDF Energy, Oil & Gas UK, Repsol Sinopec, Wood Group, ExxonMobil, Maersk, Costain, JMW, Chevron and Nexen (Oil and Gas Authority, 2019: AS).

In 2018, to complement the MER UK Taskforces, the vice president and director of Shell UK was appointed as the Industry Cultural Change Champion, whose role is to "*act as a catalyst for behaviour change to embed, sustain and accelerate the cultural change of the industry through the integration, prioritisation and sponsorship of change activities*." (Oil and Gas Authority, 2019). The MER UK Steering Group has oversight over the six MER UK Taskforces, and is also comprised of government, OGA and industry representatives. The present co-chair is the managing director of Chevron Upstream Europe. The MER UK Forum is the top-level principal platform which provides strategic direction and leads tripartite action among the UK government, the OGA and industry. It consists of a small group of representatives, meeting twice a year.

There are several case studies available from the OGA, setting out industry success in implementing the MER Strategy. The OGA also confers annual awards to companies or partnerships that have made commendable efforts in implementing the MER Strategy (Oil and Gas Authority, 2018). Below are some examples.

3.3.1 Tolmount Development

This pertains to the Tolmount Field, an undeveloped gas field in the North Sea, and is a partnership between the two equal owners of the Tolmount Field (Premier Oil and Dana Petroleum) on the one hand, and Humber Gathering System Limited (a member of CATS Management Limited group of companies) on the other hand (Oil and Gas Authority, 2018). The Tolmount Field was discovered in 2011, two appraisal wells drilled in 2013, and concept selection completed in 2016. In 2016, Premier approached CATS Management Limited for development support. CATS agreed, and Premier, Dana and

Humber entered into joint venture terms in 2018. The development will use infrastructure known as the Humber Gathering System (HGS) comprising of a Normally Unattended Installation platform and a 50 km gas export pipeline, which will connect to the Easington terminal in East Yorkshire. Premier and Dana are the licencees, with Premier being the field operator, responsible for the development plan, licence and well operations. Humber Gathering System Limited and Dana would be the infrastructure owners, with Humber the infrastructure operator. The HGS infrastructure is also designed to accommodate future in-field and third-party tie-backs. The development won the 2018 MER UK Awards for being a good example of efficient allocation of resources among UKCS players.

3.3.2 BP—ETAP

This relates to the re-use by a third party of the ETAP Central Processing Facility (CPF) which was first sanctioned in 1995 and is shared by nine different reservoirs (Oil and Gas Authority, 2018). With declining production over the years, the CPF has capacity to host third party fields, and the ETAP owners (being BP, Shell, Esso and Zennor) were approached by owners of a third-party field for a tie-back to the ETAP CPF, using the late-lie Heron subsea pipeline system (HSPS) which is owned by Shell and Esso. The benefits of using the HSPS tie-back that were identified include: material reduction in capital expenditure for the new field; an increase of about 50% in ETAP-CPF throughput and start-up of the new field; life extension of the ETAP-CPF; and deferment of the decommissioning of the HSPS.

3.3.3 Spirit Energy and OGTC New Decommissioning Technology

This pertains to the testing and development of a new disruptive decommissioning technology, which would significantly reduce the cost of decommissioning (Oil and Gas Authority, 2018). The technology uses an exothermic chemical reaction generated using thermite to create a permanent barrier in a well, by melding the well bore components and surrounding formation to recreate the cap rock. The process had been tested in Canada amid low enthusiasm among industry players for field trials. The process had been improved after further trials, but the service company supplier was reluctant to accelerate product development. Spirit Energy stepped in to form the Thermite

Collaboration Forum, with the support of the Oil & Gas Technology Centre (OGTC). OGTC was established in 2016 as a funded project of the Aberdeen City Region Deal, and is supported by the Scottish Government, UK Government, Aberdeen City Council, Aberdeenshire Council and Opportunity North East (The Oil & Gas Technology Centre, 2019). The Thermite Collaboration Forum leverages off the resources and expertise of operators and means that trials share common processes without duplication. The OGTC estimates that the new technology will have a value to the industry exceeding GB£100 million.

According to the MER UK Forum Steering Group and Taskforces Annual Update 2017, MER efforts are bearing fruit and in 2016/2017, production was at 1.63 million boepd, an increase from 1.42 million boepd in 2013/2014. Production efficiency had increased from 65% in 2014 to 73% in 2016, and average unit operating costs were at GB£12 per boe in 2017, a decrease from GB£19 per boe in 2014. The Annual Update 2017 projected that an additional 2.8 billion boe would be produced by 2050, as compared to the pre-Wood baseline forecast.

The UK MER Strategy therefore seems not only to have great government support and legislative backing, but also the support and active involvement of industry. The question then would be how the MER Strategy fits into the UK's and the global energy transition, and in particular, climate change goals under the Paris Agreement on Climate Change 2015 and the UK Climate Change Act 2008. As a background to this discussion, the following section focuses on the UK climate change goals, the Paris Agreement and the global energy transition. It should also be noted that Brexit is likely to have an impact on UK energy transition, and also on the UK MER Strategy, and this is discussed in more detail in Sect. 4.3 below.

4 The Global Energy Transition, the Paris Agreement and UK Energy Policies

4.1 The Global Energy Transition and the Paris Agreement

The energy transition has been described by the International Renewable Energy Agency (IRENA) as a pathway towards transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. At the core of the energy transition is the need to reduce carbon dioxide emissions in order to limit climate change (IRENA, 2019).

The global energy transition action can perhaps be attributed to the United Nations Framework Convention on Climate Change (UNFCCC) of 1992 (UNFCCC, 1992). Under the UNFCCC, contracting parties recognised the threat of climate change, and the fact that the largest share of GHG emissions originated and continue to originate from developed countries, and that there was need to limit GHG effects under the principle of common but differentiated responsibilities. Within the UNFCCC framework, there have been several treaties and protocols entered into by member countries relating to climate change, including the 1997 Kyoto Protocol.

Since then various countries have taken both national and multi-national measures to combat climate change. The UK has energy transition targets for a low carbon economy and climate change goals under the Climate Change Act of 2008 and the Carbon Plan 2011 (HM Government, 2011). As a member of the EU it also subscribes to EU legislation, directives and guidelines on a low-carbon transition.

The global energy transition to low-carbon and renewable energy gained further impetus in 2016, when the Paris Agreement of 2015 came into force in December 2016 (UNFCCC, 2018). The Paris Agreement was entered into to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The United States of America (USA), which indicated its intention to withdraw from the Agreement in 2017, will, under Article 28 of the Paris Agreement, have to wait for some years before it can fully withdraw. Withdrawal is provided for at any time after three years from the date that the Paris Agreement enters into force (being December 2019) and such withdrawal would be effective after one year from the date of receipt of the notification of withdrawal by the Paris Agreement depository.

The UNFCCC's main aim is the stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interferences with the climate system. Under Article 2, the Paris Agreement aims to strengthen the global response to climate change by: (a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels; (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low GHG emissions development, in a manner that does not threaten food production; and (c) Making finance flows consistent with a pathway towards low GHG emissions and climate-resilient development. Under Articles 3 and 4, each member of the Paris Agreement is required to commit to reduce GHG emissions and adapt to the impacts of climate change through NDCs, which are reflective of the different levels of development under the principle of common but differentiated responsibilities.

The UK, as a member of the EU, forms part of the EU NDC that was submitted in November 2016 on behalf of the 28 EU member states. Under the EU NDC, EU member countries aim to achieve a 40% reduction in GHG emissions by 2030, compared to the 1990 base year (UNFCCC, 2016).

Some of the measures taken by countries to limit climate change and reduce the effects of GHG emissions include a shift from fossil fuels to renewable energy; decarbonisation and electrification of transport, buildings and industry; adoption of energy efficiency technology, energy storage; carbon capture, utilisation and storage (CCUS); and use of hydrogen (IEA, 2018). It should be noted that whereas in past years, the global energy transition has been government-policy led, in recent years, technological innovation, cost efficiencies, and increasing consumer demand are driving renewables (particularly wind and solar) to be preferred energy sources. According to Bloomberg, thanks to falling costs, unsubsidised onshore wind and solar have become the cheapest sources of electricity generation in nearly all major economies of the world, including India and China. The comparative costs for power generation which are the levelised costs of electricity show that, as of 2018, onshore wind and solar were the cheapest power generation sources for all major economies except for Japan (Ross, 2018).

In its 2018 '*World Energy Outlook*', the IEA estimated that energy demand was set to grow by more than 25% to 2040, requiring more than US$2 trillion a year of investment in new energy supply. According to the IEA, governments still have a huge role to play in the global energy transition and crafting the right policies and proper incentives will be critical to meeting the common goals of securing energy supplies, reducing carbon emissions, and expanding basic access to energy across the world (IEA, 2018). Further, the IEA projects that across all regions, fuel sources and technology policy choices made by governments will determine the shape of the energy system of the future.

4.2 The UK's National Energy Transition and Climate Change Policies

As mentioned, even prior to the Paris Agreement, the UK had set goals to limit climate change and effect an energy transition under the Climate Change Act of 2008 and the Carbon Plan of 2011. More recently, in

October 2017, the UK published the Clean Growth Strategy 2017 under the Climate Change Act 2008 (HM Government, 2017). The Clean Growth Strategy was amended in April 2018 and submitted to the UNFCCC as the UK's long-term low emissions strategy under the Paris Agreement (Mead, 2018).

The Climate Change Act 2008 provides for the net UK carbon account for the year 2050 to be at least 80% lower than the 1990 UK baseline. The Act sets five-year carbon budgets for achieving the target. The goals under the Climate Change Act 2008 are repeated in the Carbon Plan 2011, and in the Clean Growth Strategy 2017. The Carbon Plan 2011 and the Clean Growth Strategy 2017 were published as part of the UK Secretary of State's obligation under the Climate Change Act 2008 to present to the Parliament reports setting out indicative annual ranges of the net UK carbon account and proposals for meeting the carbon budgets.

In addition to the above policies, the UK has formulated sectoral policies on how specific sectors would contribute to low-carbon emissions. These are set out in Table 7.2 below.

With regard to the electricity pathway, the question of energy storage would arise, and it is noted that even today, energy storage projects are on the rise (see Chap. 21 for a discussion of the role and importance of energy storage). According to trade body RenewableUK, applications for energy storage projects in the UK have grown from 2 MW in 2012, to over 6.8 GW in 2018 (Wind Power Monthly, 2018). In August 2018, the 49.9 MW Pelham project (the largest battery energy storage project in the UK) was completed (Power Engineering International, 2018). This trend is set to grow in the future.

Table 7.2 UK sectoral policies on sectoral contributions to low carbon emissions

Policy	Description
Industrial Strategy (2017)	Published in November 2017 and sets out strategies for development, manufacture and use of low carbon technologies, systems and services that cost less than high carbon alternatives (BEIS, 2017).
Road to Zero Strategy (2018)	It was published in July 2018 and aims for the UK's global leadership in the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040. The UK aims for 50%–70%, of new car sales and up to 40% of new van sales to be ultra-low emission by 2030, and to end the sale of new conventional petrol and diesel cars and vans by 2040 (Office for Low Emission Vehicles, 2018).

(*continued*)

Table 7.2 (continued)

Policy	Description
Clean Growth Strategy (2017)	2017 outlines action up to 2032, and highlights pathways to the UK's 2050 target of 80% reduction in carbon emissions. It recognises that since 1990 up to 2017, the UK had cut carbon emissions by 47%, while growing the economy by 60%. The Clean Growth Strategy 2017 (HM Government, 2017) sets out the following principle strategies and proposals: (a) Green finance, and accelerating green growth: Through financing clean technology, with a committed injection to an early stage capital fund of GBP 20 million; (b) Improving efficiency in business and industry, which account for 25% of UK emissions. This will be achieved through building regulations promoting efficiency, and industry decarbonisation plans. Within this is also a big push to fund and develop technology for CCUS. The CCUS plans include a committed GBP 100 million in CCUS innovation, so as to deploy CCUS at scale in the UK; (c) Improving efficiencies in UK homes, which account for 13% to UK emissions. This will be achieved through among others: investment of about GBP 3.5 billion to upgrade a million homes; rolling out low carbon heating; and investing more in smart metering; (d) Improving efficiencies in UK homes, which account for 13% to UK emissions. This will be achieved through among others: investment of about GBP 3.5 billion to upgrade a million homes; rolling out low carbon heating; and investing more in smart metering; (e) Accelerating the shift to low carbon transport, which account for 24% of UK emissions; achieved through the strategies set out in the Road to Zero Strategy. (f) Accelerating clean smart and flexible power, which account for 21% to UK emissions. This will involve: phasing out unabated coal power plants by 2025; exploring future nuclear power projects; increasing investment in renewable energy; providing for clarity on carbon pricing; and investing up to GBP 900 million in power sector innovation; (g) Enhancing value in from natural resources, which account for 15% of UK emissions. This will include innovation and investment in land use, including forestry, agricultural support; working towards zero avoidable waste by 2050 and managing emissions from landfill and peatland; (h) Tighter targets for the public sector, which accounts for 2% to UK emissions, and greater leadership by government. Beyond 2032, the Clean Growth Strategy 2017 offers three (3) possible pathways towards 2050: (i) Electricity pathway: In this pathway, electricity would be the main source of energy in 2050. There would be more electric vehicles, gas boilers would be replaced with electric heating and industry would move to cleaner fuels. In the pathway, by 2050, CCUS would not be in use. (ii) Hydrogen pathway: In this pathway, by 2050, hydrogen would be the main source of fuel for homes and buildings, cars and industry. Existing gas infrastructure would be adapted to deliver hydrogen. There would be a shift to using natural gas for hydrogen production and capturing the emissions with CCUS. (iii) Emissions removal pathway: Under this pathway, sustainable biomass power stations are used together with CCUS. Carbon would be removed from the atmosphere by plants (biomass) as they grow and, when the biomass is used to generate electricity, emissions would be captured by the plants (as a cycle).

4.3 The Role of CCUS in the UK's Future Energy Transition Policies

CCUS receives a huge focus under the Clean Growth Strategy 2017, as it did under the Carbon Plan 2011. Subsequent to the Clean Growth Strategy 2017, the UK government published the '*Clean Growth: UK Carbon Capture Usage and Storage Deployment Pathway Action Plan*' (the CCUS Action Plan 2018) (HM Government, 2018). CCUS is an integral component of the 3 main pathways under the Clean Growth Strategy 2017 discussed in Table 7.2 above.

Under the CCUS Action Plan 2018, the UK's ambition is to commission its first CCUS facility in the mid-2020s and deploy CCUS at scale in the 2030s (see Chap. 2 for a wider discussion of carbon capture, usage and storage). According to the Committee on Climate Change, the scale of CCUS required by 2050 may be between 60–180 MtCO2 per year (HM Government, 2018: 15).

The UK considers that CCUS is key to a least cost energy system decarbonisation pathway to 2050 and aims to invest in its development and deployment, subject to costs coming down. The CCUS Action Plan 2018 identifies amongst others the following action plans for development of CCUS to meet the needs of the Clean Growth Strategy 2017:

1. Possible sites for CCUS facilities: The main sites identified are the St. Fergus North Sea gas terminal, the Grangemouth industrial centre, the Teeside industrial centre, the Humberside industrial centre, the Merseyside industrial centre, and the South Wales industrial centre (HM Government, 2018: 16);
2. Institutions that will lead in achieving the CCUS Action Plan: These institutions comprise the government, industry, academia and professionals. They include Carbon Capture Machine (a Carbon X-Prize finalist), University of Strathclyde, University of Edinburgh, Drax (a CCUS company), University of Sheffield, University of Cambridge, Imperial College London, Aberdeen, Teeside Collective, Linklaters LLP and OGCI Climate Investments (HM Government, 2018: 17);
3. Funding for CCUS research and development: the UK government announced a GB£20 Million CCU Demonstration Programme to fund design and construction of CCU demonstration plants in the UK, a GBP 15 Million Call for Innovation Fund, and a GBP 6.5 Million contribution to the global Accelerating Carbon Technologies (ACT) research programme (HM Government, 2018: 22); and

4. Global CCUS development partnerships: The UK has in place collaboration programmes on CCUS with the IEA, the Global CCS Institute, Norway, Saudi Arabia, Mexico, the United States, and some developing countries (HM Government, 2018: 21).

Whereas the CCUS Action Plan 2018 and UK efforts to develop CCUS are laudable, it is questionable whether it is realistic to hedge the UK's future energy transition and climate change obligations on the future development of CCUS facilities that are not presently in existence.

The question of the likelihood of large scale CCUS deployment by the UK in the near future should be considered in light of the current reality. The Energy Institute, while referring to a CCUS database maintained by the Global CCS Institute noted, as of February 2019, that there were 23 large-scale CCS facilities in operation or under construction globally (Energy Institute, 2019). According to the Global CCS Institute's *Carbon Capture and Storage Readiness Index 2018* the UK was among the leaders in creating an enabling legislative and business environment for the development of CCUS. The Index noted that there were 18 CCUS operating facilities, 12 of which were located in the US and Canada, and that these facilities had been initially developed for purposes of enhance oil recovery, and not climate targets. In relation to the status of CCUS in meeting climate targets, the Index concluded that, '*no nation, including the leaders, have yet established the conditions necessary to drive deployment at the rate required to meet ambition climate targets*' (Global CCS Institute, 2018).

Considering the above, it remains to be seen whether the UK's CCUS ambitions under the CCUS Action Plan 2018 and the Clean Growth Strategy 2017 are achievable within the timelines required to fulfil the UK's climate targets.

4.4 Brexit and UK/EU Energy Transition Relations

There is wide-ranging discussion as to the impact of Brexit on the UK and EU climate change goals. On the 26th June 2016, a UK referendum on whether to leave or remain in the EU voted by a slim majority of 51.9% to leave the EU. On the 29 March 2017, the UK, formally commenced the process under Article 50 of the Lisbon Treaty of 2007 (Hunt and Wheeler, 2019). The UK was set to formally leave the EU on the 29th March 2019, under the 2-year process in Article 50, although this period has already been extended (BBC News, 2019) and might be further extended until the end of the year or 2020 depending on the EU and the UK Government (The Guardian, 2019). It should be noted that by the time of publication the status of Brexit may change, including the likelihood that Brexit may occur at a date later than the dates referred above, or may not occur at all.

As a current member of the EU, the UK is subject to EU energy and climate change policies, legislation and programmes, including: the EU Emissions Trading Scheme (EU ETS); the European Atomic Energy Community; the EU Third Energy Package, and several EU directives, including the EU Renewable Energy Directives, the Clean Energy Package and the EU Industrial Emission Targets Directive 2010. The 5th Carbon Budget adopted in 2016 assumes continued participation of the UK in the EU ETS and the House of Commons Business, Energy and Industrial Strategy Committee had in the past recommended remaining in the EU ETS at least until 2020 (Norton Rose Fulbright, 2018).

The Clean Growth Strategy 2017 recognises that Brexit will have an impact on the UK's energy policies, but stresses this will not affect the UK's commitments to climate change, since the targets under the Climate Change Act 2008 are more ambitious than the EU NDC under the Paris Agreement. Saying that, the Clean Growth Strategy 2017 notes four areas where the UK's emissions policies rely on EU mechanisms:

1. EU ETS, which accounts for about 40% of UK emissions under carbon budgets;
2. New car and van carbon regulations, and EU fluorinated gas quotas;
3. EU products policy which sets minimum standards for a range of products relating to energy efficiency; and
4. Non-energy and climate EU frameworks such as the Common Agricultural Policy.

The Clean Growth Strategy 2017 acknowledges that current UK energy transition and climate change policies consider EU policies, and that detailed future policies will be formulated as the UK negotiates a post-Brexit deal with the EU.

Having discussed the MER Strategy, the global energy transition and the UK energy transition and climate change goals, the question that arises then is whether the MER Strategy is in line with the UK's energy transition and climate change obligations internationally under the Paris Agreement, and nationally under the Climate Change Act 2008. The next section analyses and seeks to offer an answer to this question.

5 The MER Strategy Versus The Global Energy Transition

5.1 The Impact of the MER Strategy on Energy Transition and Climate Change Targets

Can the UK successfully implement the MER Strategy in light of the UK energy transition and climate change commitments under the Paris Agreement and the Climate Change Act 2008? This question has drawn varied reactions.

In 2015, Client Earth, a climate change NGO, referring to the provisions of the then Infrastructure Bill (now the Infrastructure Act 2015) which legislate the MER Strategy, noted that, "*if more fossil fuels are extracted, more will be burnt. Whether they are burnt at home or abroad, the detrimental effect on climate is the same. And if they won't be burnt, they shouldn't be extracted in the first place*" (ClientEarth, 2015).

The 2014 Wood Review estimated that implementation of the MER Strategy would recover 3–4 billion boe more than would otherwise be recovered by 2035. The 2017 Vision 2035 Annual Update estimated that an additional 2.8 billion boe would be produced by 2050, as compared to the pre-Wood baseline forecasts. Irrespective of whether these billions of boe are burnt in the UK or exported, does the UK energy and climate change policy sufficiently cater for limiting the carbon emissions arising from this?

In its 2014 response to the Wood Review, the UK government noted the MER Strategy was in line with achieving the objectives under the Carbon Plan 2011, which shows that the UK will still need significant oil and gas supplies over the next decades while it pursues decarbonisation efforts and transitions to a low carbon economy (DECC, 2014). The Carbon Plan 2011 recognised that the UK would need oil and gas supplies as it transitions, so as to avert threats to energy security (HM Government, 2011). The Carbon Plan 2011 noted three challenges to the UK's energy security, as follows:

(a) It was projected that by 2020, the UK could be importing 50% of its oil and 55% more of its gas. This would be amid risks of volatile energy prices and physical disruptions caused by rising global demand and geopolitical instability;
(b) It was estimated that the UK would lose a fifth of its electricity generating capacity due to closure of coal and nuclear plants; and
(c) It was projected that even though dependence on imported energy would fall in the long term, the UK would face a challenge in balancing inter-

mittent energy supplies from renewables. The UK energy system therefore needed to be resilient to mid-winter peaks in heating demand and intermittent electricity supply due to low wind speeds.

The Carbon Plan 2011 noted that even in 2050, gas would still contribute to electricity generation in power stations fitted with carbon capture and storage (CCS) technology, as a back-up for intermittent renewables electricity supply (HM Government, 2011). As discussed in the Clean Growth Strategy 2017, CCUS is projected to play a key role in limiting climate change, and under the CCUS Action Plan 2018, the UK's ambition is to commission its first CCUS facility in the mid-2020s and deploy CCUS at scale in the 2030s.

The Clean Growth Strategy 2017 suffered an indictment when the Committee on Climate Change advised that the Strategy falls short of meeting the Fourth and Fifth Carbon Budgets, even when taking a 'generous' view of the plans and policies it sets out. The UK Committee on Climate Change criticised the Clean Growth Strategy 2017 as relying on surpluses from previous carbon budgets, which are based on changes to the UK's share of the EU ETS and the 2008 financial crisis, rather than from early climate action (Carbon Brief, 2018).

It should also be noted that depending on the Brexit deal agreed, this will have an impact on the UK's climate targets, and benefits from the MER Strategy and Vision 2035. The EU ETS currently accounts for about 40% of UK emissions under the carbon budgets. How will this play out after Brexit?

Ultimately, even in the application of the MER Strategy, the UK will be required to follow the legal requirements of the Climate Change Act 2008, and its commitments under the Paris Agreement. Indeed, one of the MER Strategy Safeguards is that no conduct can be required under the MER Strategy which would be prohibited under any legislation, including legislation on environmental protection. In 2015, Client Earth also stated that although legislation in 2015 to expand fossil fuel recovery was questionable, the UK's climate change commitments remained the predominant guide to UK energy policy.

Energy security is an important consideration for the UK and is a driving force for the MER Strategy. However, it appears that whether the MER Strategy is in line with the UK's climate change commitments depends on the UK's ability to use CCUS to offset the carbon emissions arising from the consumption of the oil and gas that will be recovered from the UKCS. This will not be without challenges.

Noting that the UK presently does not have a developed CCUS facility, and noting that globally, there are only 18 large-scale CCS facilities (Global

CCS Institute, 2018), it is questionable whether the UK can develop CCUS technology and facilities fast enough to fulfil the estimate 60–180 MtCO2 per year CCUS required by 2050 in order to fulfil the UK's climate change obligations (HM Government, 2018: 15).

5.2 The UKCS to 2050 and Beyond—Life During and After MER

During MER, end of life assets and infrastructure will continue to require decommissioning. Further, the MER Strategy and Vision 2035 give projections for MER up to 2050. The 2017 Clean Growth Strategy's possible pathways towards 2050 project either an electricity pathway where fossil fuels and CCUS will no longer be in use; a hydrogen pathway where gas will no longer be in use; or an emission reduction pathway that will be heavily reliant on biomass and CCUS, rather than oil and gas. Options for use of the UKCS beyond decommissioning, and beyond the MER Strategy, will therefore still need to be considered.

How can assets and infrastructure in the UKCS be best utilised in light of the energy transition? Several options have been considered by the UK and the EU, relating to the multi-use of offshore platforms.

In principle, Multi Use Platform (MUP) concepts integrate different maritime economic activities (such as oil and gas, renewable energy, fishing and tourism) within the same space. In line with the EU's Blue Growth Strategy, this business model provides a series of potential advantages: efficient use of marine space, sharing of risks and costs, sharing resources, reduced environmental impacts, and enhanced socio-economic benefits (Maritime Forum—European Commission, 2018).

Delivering this vision will require tools that identify viable multiuse combinations allowing for the optimal use of sea space. For instance, oil and gas pipelines can probably be used to store energy or transport hydrogen. Additionally, old platforms, which are in close proximity to new wind farms, could be re-used as sub-stations. In practice however, multi-use is still at the inception stages though there have been some notable pilot projects which have gleaned some valuable information. These include:

5.2.1 The EU-Backed Mermaid Project (Vliz.be, 2015)

This project looked at how multi-use platforms could be developed around the European coast. It tested uses of platforms in the Baltic Sea, the Wadden

Sea off the Dutch coast, the Atlantic Ocean (Bay of Biscay) and the Mediterranean. The different platforms combined wind turbines and fish farming, and seaweed farming and wave energy. The project found significant benefits in terms of efficiencies arising from shared infrastructure, resources and services (such as maintenance services).

5.2.2 The Space@Sea Project (Space@Sea, 2017)

This project is also EU backed and runs until 2020 and is working on the creation of a concept of a low ecological impact island that could be deployed at sea and would have such combined uses as energy and transportation hubs, as living space and for food production.

5.2.3 Algae Production

The possibilities for using algae production in the North Sea are also being examined; algae produce proteins that can be useful to the pharmaceutical sector and be used as bio-fuel for cars or electricity plants. The resulting CO_2 emissions can then be degraded in equal measure (PwC, n.d.).

5.2.4 The MUSES (Multi-Use in European Seas) Project Under the European Commission Maritime Forum

The project was concluded in 2018 and studied the organisational and legal challenges which inhibit the uptake of MUP. The project set out different groups of recommended measures for multi-use projects, depending on the combination of activities, for example, wind energy and fish farming or algae production. It concluded that a strategic approach to multi-use is critical in order to accommodate the organisational, legal and environmental considerations across numerous regimes.

There are challenges to the uptake of MUP, which are mostly of an organisational and legal nature. This is especially so where different activities in the seas are subject to different permitting regimes and regulatory processes. Such obstacles might mean that the costs of installing a MUP will be high relative to separate single-use platforms, even though the ongoing costs of running MUPs might be lower. The MUSES project set out that a strategic approach to accommodate legal and organisational differences across different regimes is critical (Maritime Forum—European Commission, 2018).

6 Conclusion

This paper has sought to answer the question of whether the UK can successfully implement the MER Strategy in light of the UK energy transition and climate change commitments under the Paris Agreement and the Climate Change Act 2008 and other UK policies.

Section 1 introduced this paper. Section 2 provided an understanding of the UKCS, its historical contribution to the UK economy and energy security, and the decline of the UKCS production. In doing so, the section provided a background into the motivation behind the formulation of the UK MER Strategy.

Section 3 discussed the MER Strategy, including a discussion of the background of the MER Strategy as conceptualised by the 2014 Wood Review. It analysed in detail the components of the MER Strategy and discussed the various obligations of the UK government and licencees and examples of the MER Strategy in practice. In particular, this section notes that with the cooperation and collaboration among licencees and the government in pursuing the MER objectives, the strategy is underway to achieve maximum economic recovery objectives under both the MER Strategy and Vision 2035, leading to recovery of an estimated 3–4 billion barrels of oil equivalent more than would otherwise be recovered by 2035, and more by 2050.

Section 4 discussed Paris Agreement climate change commitments, the global energy transition and the UK energy transition goals. The main goal of the Paris Agreement is to reduce the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The UK has emission reduction targets of 80% lower than the 1990 baseline. This Section explained the various low-carbon strategies engaged globally and by the UK to reduce carbon emissions, including uptake of renewable energy, use of hydrogen and the robust development of CCUS. The Section also discussed the impeding impact of Brexit on the UK climate change and energy transition goals.

Section 5 critiqued the UK MER Strategy and its compatibility with the global and UK energy transition and climate change objectives. The Section concludes that energy security is indeed an important consideration for the UK and is a driving force for MER UK. However, whether the MER Strategy is in line with the UK's climate change commitments depends on the UK's ability to use CCUS to offset the carbon emissions arising from the consumption of the oil and gas that will be recovered from the UKCS. The UK presently does not have a developed CCUS facility, and globally, there are only 18 large-scale CCS facilities. Considering this, it appears questionable whether the UK can develop CCUS technology and facilities fast enough to fulfil the estimate 60–180 MtCO2 per year CCUS required by 2050 in order to fulfil the UK's climate change obligations.

In order for the UK to retain the MER Strategy whilst keeping true to its climate change and energy transition obligations and objectives, the UK would need to do much more to champion sector-wide energy efficiency efforts and highly innovative low-carbon and emissions removal technology. This will require substantial financial investment in billions of pounds, policy and institutional support from government and private sector buy-in. Further, the UK would still need to consider options for the UKCS beyond MER UK, and amid the country's 2050 low-carbon pathways. Can achieving the MER Strategy hand in hand with the UK's climate targets be a practical reality, or will it be like sighting a mermaid in the sea? This remains to be seen.

References

BBC News. 2019. *May Offers MPs Brexit Delay Vote*. https://www.bbc.com/news/uk-politics-47373996.

Butler, N. 2016. Can the North Sea Avoid Decline? *Financial Times*. Ft.com. https://www.ft.com/content/c920bab0-81b2-3061-8ef8-f12cca379006.

Carbon Brief. 2018. UK Will Miss Climate Goals Despite New Strategy, Says Official Watchdog. *Carbon Brief*. https://www.carbonbrief.org/uk-will-miss-climate-goals-despite-new-strategy-says-official-watchdog.

ClientEarth. 2015. *The Infrastructure Bill and the Climate Change Act—A Bump in the Road, Not a U-turn*. https://www.clientearth.org/infrastructure-bill-climate-change-act-bump-road-not-u-turn/.

Department for Business, Energy and Industrial Strategy (BEIS). 2017. *Industrial Strategy: Building a Britain Fit for the Future*. https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future.

Department for Business, Energy and Industrial Strategy (BEIS). 2018. *Digest of United Kingdom Energy Statistics 2018*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728438/DUKES_LTT.pdf.

Department of Energy and Climate Change. 2014. *Government Response to Sir Ian Wood's UKCS: Maximising Economic Recovery Review*. DECC. https://www.ogauthority.co.uk/media/1018/wood_review_government_response.pdf.

Eisourcebook.org. 2015. *The UKCS Designations*. http://www.eisourcebook.org/cms/December%202015/UK%20Continental%20Shelf%20Designations%202015.pdf.

Energy Institute. 2019. *Energy Insight: Carbon Capture and Storage (CCS) and Carbon Capture Usage and Storage (CCUS) in the UK*. https://knowledge.energyinst.org/search/record/_nocache?id=111292&utm_source=SZY+-+Energy+Futures&utm_campaign=052bab1cca-EMAIL_CAMPAIGN_2018_08_01_01_45_COPY_01&utm_medium=email&utm_term=0_887519ca7e-052bab1cca-67059511.

Forbes. 2019. *Sir Ian Wood*. https://www.forbes.com/profile/ian-wood/#1f2897c348dd.

Global CCS Institute. 2018. *The Carbon Capture and Storage Readiness Index 2018*. http://decarboni.se/sites/default/files/publications/202108/ccs-readiness-index-2018global-ccs-institute-2018digital.pdf.

HM Government. 2011. *Carbon Plan 2011*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf.

HM Government. 2017. *The Clean Growth Strategy*. https://www.gov.uk/government/publications/clean-growth-strategy.

HM Government. 2018. *Clean Growth: UK Carbon Capture Usage and Storage Deployment Pathway Action Plan*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759637/beis-ccus-action-plan.pdf.

House of Commons Library (UK). 2018. *Future of the UK Oil and Gas Industry*. CDP 2018/0210. UK House of Commons Library. https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CDP-2018-0210.

Hunt, A. and Wheeler, B. 2019. Brexit: All You Need to Know About the UK Leaving the EU. *BBC News*. https://www.bbc.com/news/uk-politics-32810887.

International Energy Agency (IEA). 2017. *WEO 2017: Key Findings*. https://www.iea.org/weo2017/.

International Energy Agency (IEA). 2018. *World Energy Outlook 2018 Examines Future Patterns of Global Energy System at a Time of Increasing Uncertainties*. https://www.iea.org/newsroom/news/2018/november/world-energy-outlook-2018-examines-future-patterns-of-global-energy-system-at-a-t.html.

International Renewable Energy Agency (IRENA). 2019. *Energy Transition*. https://www.irena.org/energytransition.

Legislation.gov.uk. 1964. *Continental Shelf Act 1964*. https://www.legislation.gov.uk/ukpga/1964/29.

Legislation.gov.uk. 1998. *Petroleum Act 1998*. https://www.legislation.gov.uk/ukpga/1998/17/part/1A.

Maritime Forum—European Commission. 2018. *Multi-use Ocean Platforms: An Emerging Concept*. Maritime Forum, European Commission. https://webgate.ec.europa.eu/maritimeforum/en/node/4259.

Mead, L. 2018. UK Submits Long-term Strategy to Achieve Climate Goals Under Paris Agreement. *News, SDG Knowledge Hub, IISD*. http://sdg.iisd.org/news/uk-submits-long-term-strategy-to-achieve-climate-goals-under-paris-agreement/.

Norton Rose Fulbright. 2018. *Impact of Brexit on the Energy Sector*. https://www.nortonrosefulbright.com/en/knowledge/publications/686cd7c7/impact-of-brexit-on-the-energy-sector.

Office for Low Emissions Vehicles. 2018. *Reducing Emissions From Road Transport: Road to Zero Strategy*. https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy.

Oil and Gas Authority. 2016. *The Maximising Economic Recovery Strategy for the UK*. https://www.ogauthority.co.uk/media/3229/mer-uk-strategy.pdf.

Oil and Gas Authority. 2018. *MER UK Awards*. https://www.ogauthority.co.uk/news-publications/mer-uk-awards/.

Oil and Gas Authority. 2019. *MER UK Forum and Taskforces*. https://www.ogauthority.co.uk/about-us/mer-uk-forum-task-forces/.

OilPrice.com. 2018. UK North Sea Oil Production Set To Resume Decline In 2019. *OilPrice.com*. https://oilprice.com/Energy/Energy-General/UK-North-Sea-Oil-Production-Set-To-Resume-Decline-In-2019.html.

Power Engineering International. 2018. *Largest Battery Storage Project in UK is Unveiled*. https://www.powerengineeringint.com/articles/2018/07/largest-battery-storage-project-in-uk-is-unveiled.html.

PwC. n.d. *Energy Transition in the North Sea*. https://www.pwc.nl/en/industries/energy-utilities/energy-transition/energy-transition-in-the-north-sea.html.

Ross, K. 2018. *Solar and Wind Now the Cheapest Power Source Says BloombergNEF*. https://www.powerengineeringint.com/articles/2018/11/solar-and-wind-now-the-cheapest-power-source-says-bloombergnef.html.

Space@Sea. 2017. *About SPACE@SEA*. https://spaceatsea-project.eu/about-space-at-sea.

The Guardian. 2019. EU to Decide on UK's Brexit Extension, Wed April 10, 2019. https://www.theguardian.com/politics/live/2019/apr/10/brexit-eu-to-decide-on-uk-extension-live-news.

The Oil & Gas Technology Centre. 2019. *Overview—Oil & Gas Technology Centre*. https://www.theogtc.com/about-us/overview/.

UK Oil and Gas Industry. 2016. *Vision 2035*. https://www.ogauthority.co.uk/about-us/vision-2035/.

United Nations Framework Convention on Climate Change (UNFCCC). 1992. *The UNFCCC*. https://unfccc.int/documents?search2=&search3=United%20National%20Framework%20Convention&f%5B0%5D=document_type%3A353&page=0%2C0%2C1.

United Nations Framework Convention on Climate Change (UNFCCC). 2016. *European Union NDC*. https://www4.unfccc.int/sites/NDCStaging/Pages/Party.aspx?party=GBR.

United Nations Framework Convention on Climate Change (UNFCCC). 2018. *The Paris Agreement*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

Vliz.be. 2015. *EU Mermaid Project*. http://www.vliz.be/projects/mermaidproject/.
Wind Power Monthly. 2018. *Massive Energy Storage Growth Expected in UK*. https://www.windpowermonthly.com/article/1498021/massive-energy-storage-growth-expected-uk.
Wood, S. 2014. *UKCS Maximising Recovery Review: Final Report*. https://www.ogauthority.co.uk/media/1014/ukcs_maximising_recovery_review.pdf.
Wood Group. 2019. *Wood Group*. https://www.woodplc.com/who-we-are/about-us

8

Enacted Inertia: Australian Fossil Fuel Incumbents' Strategies to Undermine Challengers

Marc Hudson

1 Introduction

The need for a transition to sustainability is well understood (Jenkins et al., 2018). For the last four decades—and especially since 2006—pleas and exhortations for a new set of economic and cultural institutions to sustain human civilisation have become routine (Gough, 2017; Raworth, 2017). Given that a large proportion of anthropogenic greenhouse gas (GHG) emissions come from the use of fossil fuels to provide either propulsive energy or for electricity generation, the energy sector is often studied as one sector in need of rapid transformation.

There is burgeoning interest in the subject of power within sociotechnical transitions (Avelino, 2017) because those who own the infrastructure—of extraction, distribution or retail—are, understandably, keen to continue their profitable business, and have acted extremely effectively in their own defence. The means by which they do this have been studied by journalists and academics. The effectiveness of the 'carbon club' (Legget, 1999) is outlined in journalistic exposes (Gelbspan, 1998, 2004; Goodell, 2007), and more scholarly works (Oreskes and Conway, 2010; McCright and Dunlap, 2010). In order to incentivise, accelerate (or at the very least manage) the decline of incumbents, it is necessary to understand their, past, current and potential defensive strategies.

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This chapter outlines the political, economic and cultural strategies and tactics deployed by them and their proxies in their (largely successful) efforts at slowing the Australian energy transition. By incumbents I mean industry actors (CEOs, business lobby groups) who profit from the status quo, and political actors (politicians, bureaucrats) who defend that status quo from self-interest and/or ideological commitment. In addition to a practical contribution, it helps thicken our understanding of power and agency within socio-technical transitions, and the role of the state within transitions (Johnstone and Newell, 2018). The data for the chapter drawn from interviews and archival research conducted during the author's PhD research. This includes other researchers' PhD theses, which are rich sources of quotations from industry actors (Pearse, 2005; Sharova, 2015).

Australia is a special case; it is particularly vulnerable to climate impacts, has virtually unlimited supplies of sun and wind for renewable energy generation but its per capita GHG emissions are the highest in the OECD (Organization for Economic Cooperation and Development) , despite policy-maker awareness of anthropogenic global warming dating back more than 30 years (Hudson, 2017c). The cause of this seeming paradox is Australia's reliance on coal and natural gas for electricity generation which gives enormous potential power to the specific businesses. (Hamilton, 2001, 2007; Pearse, 2005, 2007, 2018; Taylor, 2014; Sharova, 2015). Alongside wind and solar, Australia has superabundant quantities of black and brown coal, and natural gas. The world's largest coal exporter since 1984, it has built enormous Liquefied Natural Gas (LNG) export infrastructure over the last decade. Many have noted the enormous inertia in the energy system, but this inertia has to be constantly (re)-enacted and re-enforced.

Australia has been a Federation since 1901, comprising six states and two territorial governments which guard their powers carefully. Its constitution is silent on environmental matters, and states have jealously guarded their prerogatives. Although the Federal government does in theory have the legal power to halt environmentally-damaging projects, it has been extremely reluctant to invoke these legal powers. A mining boom in the 1960s and 1970s, followed by restructuring of the Australian economy (Kaptein, 1993) did nothing to alleviate these state-Federal tensions. Government switches between the Australian Labor Party (ALP)—a nominally left-centrist party, and the Coalition, made up of a free-market Liberal Party and the socially conservative National Party.

Awareness of possible climate impacts caused by anthropogenic human-caused gas emissions is hardly new (Table 8.1). An April 1957 *Sydney Morning Herald* front page story warned of it (Anon, 1957). Concerns about climate

Table 8.1 Timeline for climate change issues in Australia (1969–2017)

Year	Description
1969	Australian scientists begin to alert policymakers to the existence of a long-term problem.
1988	Climate change first becomes a salient public policy issue.
1990	Australia announces an 'interim planning target', with caveats about not taking actions which would harm the Australian economy.
1992	Australia ratifies the UNFCCC. A domestic policy, the National Greenhouse Response Strategy, made up of only voluntary measures, is agreed.
1995	The Keating Government briefly considers imposing a small carbon tax to fund research and development into renewable energy and energy efficiency.
1997	Australia secures extremely generous terms at COP3.
2002	Prime Minister Howard announces Australia will not ratify the Kyoto Protocol.
2003	Prime Minister John Howard personally vetoes a carbon pricing scheme put to him by at least five members of his cabinet.
2006–2007	Climate change becomes a highly salient political and economic issue.
2010	Kevin Rudd's abandonment of the Carbon Pollution Reduction Scheme leads to a dramatic drop in his personal approval ratings.
2011	Minority ALP government led by Julia Gillard passes carbon pricing legislation.
2014	Incoming LNP government, led by Tony Abbott repeals 'carbon tax'.
2017	Climate review says Australia on track to meet international obligations.

change were a (minor) part of the general awareness of environmental problems (air and water pollution, habitat destruction, overpopulation) in the late 1960s and early 1970s. In the late 1980s and early 1990s policy options—including carbon pricing—were mooted. Voluntary rather than mandatory programs were chosen, and emissions grew almost as steeply as Australia's coal exports.

Since the climate issue (re) emerged in late 2006 (Hogarth, 2007), the Australian political elite has grappled incessantly with policy responses (Hudson, 2019). From December 1975 to November 2007 (32 years) Australia had four Prime Ministers: from June 2010 to the present it has had five, with climate change being intimately tied to the demise of three—Howard, Rudd, and Gillard (Hudson, 2015b). Prime Minister John Howard lost his job in part because of the perception that he did not take climate change seriously (Rootes, 2008). His successor, Kevin Rudd, promised to do so, and saw his popularity collapse when he shelved an Emissions Trading Scheme (ETS) in April 2010. His deputy, Julia Gillard, toppled him and introduced an ETS in the face of enormous media and political opposition.

It was abolished by the next Prime Minister, Tony Abbott (for accounts of some of these battles, see Chubb, 2014; Kelly, 2014; Combet, 2015; Gillard, 2014).

The chapter proceeds as follows. Three sets of strategies—political, economic and cultural—that Australian incumbents have used in their startlingly successful battle against the rise of the climate issue and renewable energy, are explored in turn. Then, based on observed trends and speculations, their possible future actions are outlined.

2 Political Strategies

Australian incumbents have an almost thirty-year history of success in blocking, weakening, delaying or shaping policy responses to climate change. They have ensured that any policies ultimately agreed contained significant caveats and loopholes to allow 'business as usual'. While not a radical policy in-and-of-itself, carbon pricing could begin to undermine their business model and crucially support economic competitors. Specific policies supporting renewable energy have been retarded in their development, grudgingly implemented and then endlessly reviewed and changed, leading to investment droughts. Institutions created to support renewables have been de-funded, their remits changed to undermine their efficacy. Incumbents have worked to ensure that National Electricity Market (NEM) rules favour large, centralised fossil fuel generators, making market entry harder for decentralised and renewable sources. To achieve this, they have used the bureaucratic dark arts: lobbying, supplemented with economic modelling, 'hearts and minds' publicity campaigns which either burnish their industries or attack proposals for change; and the creation of organisations that will put the case to policy networks or beyond.

This section looks at the actions of industry incumbents lobbied policy networks and policymakers (Federal and state Governments) to achieve its goals. While there is overlap and occasional synergy with actions taken to influence the public, those will be discussed in the section on cultural strategies. The section is broken down into actions facing federal governments, state governments, and those taken to ensure business 'sings from the same hymn sheet'.

Before discussing these, a conceptual point around the nature of the state needs to be explained. The state has consistently been 'black-boxed' as a neutral arbiter of competing forces. However, the Australian state (Federal or state-level) has always been intensely developmentalist (pro-industry). This is exemplified by an anecdote from the earliest days of climate policy; in 1987 a document on Australia's energy prospects—*Energy 2000*—was in drafting mode. An industry insider told a researcher that one chapter was removed because:

> the then senior public servants perceived it as their patriotic duty to prevent the coal industry from being undermined by an untoward focus on something that in their thinking was a load of cobblers… their perception, and I don't think you could even argue that it was because they were under intense lobbying pressure from the coal industry. I think it was very much a matter of some senior and quite strong public servants taking it into their heads that having a whole chapter in something like this on greenhouse was just plain wrong, so they took it out, or they persuaded the minister of the day. (Pearse, 2005: 327–328)

The role of bureaucrats in shelving, weakening and delaying policy responses (witnessed again in 1991/2 as Australia developed its 'National Greenhouse Response Strategy') is too easily overlooked.

3 Facing Federal Governments

The primary strategy used by business incumbents has been concerted and coordinated lobbying of selected ministers and senior bureaucrats, almost always backed up by economic modelling. The modelling argues that the proposals being put before the government, whether by environmentalists or Treasury, would cause economic catastrophe for Australia's resources sector, and increase electricity prices.

Industry lobbying became steadily more coordinated as environmental issues and sustainability gained centre-stage in the years 1988–1989. The Business Council of Australia (BCA), comprised of the CEOs of the biggest companies, led the way with the creation of an Environmental Taskforce. This enabled the mining sector to combine with other sectors (manufacturing, retail, etc.) to present a loud, unified voice during the 'Ecologically Sustainable Development' process initiated by Prime Minister Bob Hawke. In mid-1991 Hawke used his personal authority to ban uranium mining in Kakadu National Park. The decision so shocked the mining industry that leading actors formed the Australian Industry Greenhouse Network (AIGN). Initially a 'clearing-house' for information, it proved its worth in 1994/5 when it coordinated responses to a proposed carbon tax under Hawke's Labor successor, Paul Keating.

The apotheosis of the AIGNs power occurred during the 11-year reign of Liberal Prime Minister John Howard. Various industry insiders told Pearse (2005) that they could side-line successive Environment Ministers' various proposals by using their intimate contacts within the bureaucracy: "*You name it—and if we wanted to put a spoke in the wheel of Robert Hill or whatever we could do it pretty quickly!… we reverse-managed that ministerial (greenhouse) committee so many times*" (Pearse, 2005: 194).

Aware of what was going on at critical points, AIGN lobbyists claimed they could "*produce other pieces of consultants work which we thought they should have been doing or we would advise the Prime Minister's office and various other people about the fact that these things were going on*" (Pearse, 2005: 318). Another interviewee confirmed that AIGNs lobbyists had been involved in writing Cabinet submissions, vetting Cabinet briefs before they were presented and even writing policy (Pearse, 2005: 318). Pearse argues that a 'reverse capture' had taken place, in which former bureaucrats now working in industry could "*exert a pervasive influence on the positions advanced to government by the departments in which they once worked*" creating "*policy cul de sac*" in which policies unfriendly to industry were "*stifled*" (Pearse, 2005: 336–337).

After Howard lost office in 'the first climate change election' (Rootes, 2008) incumbents' old methods were no longer adequate. The new Prime Minister, Kevin Rudd, labelled climate change the "great moral challenge of our generation" and proposed a Carbon Pollution Reduction Scheme (CPRS). Over the two years that the scheme was developed, through green papers and white papers, and draft legislation, industry, especially the Minerals Council of Australia (MCA) lobbied for concessions, exemptions and delay. Midway through the process, renowned Australian economist Ross Garnaut described the lobbying effort as "*the most pervasive vested-interest pressure on the policy process since the Scullin Government and… the most expensive, elaborate and sophisticated lobbying pressure on the policy process ever*". He observed that "*Never in the history of Australian public finance has so much been given without public policy purpose, by so many, to so few*" (Garnaut, 2008).

Rudd's successor, Julia Gillard took a different approach. To form a minority government, she relied on various independent and Green MPs. They demanded a Multiparty Committee on Climate Change (MPCCC). Frank Jotzo, a professor at Australian National University, noted that:

> There was very little outside involvement during the period of negotiations. They had a Cabinet-level committee [MPCCC] to agree the scheme, and *during that period there was no opening to business lobbies. They didn't tell anyone what*

> *they were doing. There were no drafts, no scheme proposals that the businesses could react to*. They just came out and announced the final agreement. It was quite an unusual way of doing it. (cited in Sharova, 2015: 71, emphasis added)

Greg Combet, Gillard's Climate Minister, recounts: "*the meetings with the coal industry were particularly difficult and they were very aggressive. Let's say I was shocked at how rude some of the executives were*" (Priest, 2013).[1] Unable to influence the process using their favoured methods, industry resorted to a massive 'hearts and minds' campaign.

With the return to a federal Coalition government, fossil fuel incumbent lobbyists regained favoured access. Prime Minister Tony Abbott repealed Gillard's ETS in 2014. When Abbott's vanquisher Malcolm Turnbull won office, he appointed the MCAs former head of climate and environment as his climate and energy adviser (Slezak, 2017).

One important supplement to lobbying has been the use of economic modelling to assert that greenhouse policies would cause economic meltdown. The earliest example came in 1989, when the mining company CRA (since renamed Rio Tinto) commissioned a report on the costs of meeting an early proposed international target (Marks et al., 1989). Since then, modelling, often produced in flurries ahead of policy decisions, has been used in policy discussions and also given to sympathetic (and credulous) journalists who write 'the sky will fall' articles around impacts on growth, employment and tax revenues. Traditionally, the modelling makes three assumptions—a lack of other policy responses, already perfect energy efficiency, and ongoing high costs of renewable energy (see Diesendorf, 1998; Parkinson, 2017a).

The discursive uses of modelling are best captured by economist Richard Denniss, who remembers meeting his first client:

> When I had spent a few minutes outlining what I saw as the strengths and weaknesses of the possible methodological options, the client interrupted: "Look, mate," he said, "all I want is something about an inch thick. I want to walk into a meeting, slam it on the fucking table, and say, 'According to my economic modelling'." (Denniss, 2015)

[1] In his preface to the memoir of his chief of staff, published in 2015, Combet goes further: "*As a minister, I was quite often astounded by the audacity of the claims. Large global companies were at times outrageous, patronising while simultaneously demanding money. One international coal-mining executive, while toying with immaculately jewelled cufflinks, contemptuously dismissed the government's right to legislate a price for carbon pollution while conceding that his company had been factoring a carbon price into investment decisions for years*" (Behm, 2015: vii). Behm himself concurs. For instance: "*It was particularly surprising to find Mick Davis, the CEO of the then-international mining giant Xstrata (taken over by Glencore in 2013), unable to disguise his disdain and contempt for both Combet and Gillard when he called on them in 2010. Why did he bother the call when all he was able to do was look scornful?*" (Behm, 2015: 175).

With the connivance of government, the fossil fuel industry particularly targeted renewables policy. A Federal Renewable Energy Target was introduced in 2001 and subjected to repeated review. Leaked minutes reveal that in 2004 Prime Minister Howard called a meeting of senior fossil fuel executives, seeking their help in undermining the target (ABC, 2004). When, under Julia Gillard, two new organisations—the Australian Renewable Energy Agency and the Clean Energy Finance Corporation (CEFC)—were created, the Green Party insisted they not be under control of the Minister for Energy, who they perceived as a fossil fuel ally—upon retiring from parliament he became CEO of the Queensland Resources Council (QRC). The Abbott government unsuccessfully attempted to close both but was unable to do so. Instead, Abbott changed the CEFCs remit to enable funding of 'clean coal'.

4 Facing State Governments

Lobbying, supplemented by economic modelling, works at least as well at a State level as it does at Federal (Mitchell, 2012). Former New South Wales (NSW) premier Nick Greiner stated:

> The truth is the states are closer to the ground, so there is an easier potential [for corruption] in terms of planning decisions and allocation of mining rights and indeed with gambling. They are qualitatively different from the Commonwealth, which is removed from real-world economic decisions. (Manning, 2014)

Another great source of (presumed) influence is party donations. As Bernard Keane (Keane, 2012) notes: "*Mining company donations to state and federal Labor parties and the Coalition since 2004 show the extent to which Coalition benefited from the surge in mining company largesse after the Rudd government infuriated them with its* [mining tax] *proposal in May 2010*".

There have been occasions—especially in the carbon tax battle of 1994/5 and again in 2008/9 and 2011 under Rudd and Gillard respectively—when incumbents used state government uncertainty and antipathy over Federal government interference in what they saw as their developmentalist prerogatives to good effect. In 1994/5 AIGN members lobbied state governments (especially Victoria, Queensland and Western Australia) to apply pressure on the Federal Government.

Incumbents, via organisations such as the QRC and the New South Wales Minerals Council, also engage in a steady stream of press releases, conferences, and reports which burnish their industries and attack their opponents as ill-informed, elitist or even agents of foreign powers.

5 Organising and Dis-Organising Policy Contestation

Incumbents face the same kinds of problems—around outliers, free-riders, etc.—as other collective actors. To overcome these, they perform (at least) three different kinds of action: mobilising existing organisations, defending these from attack/capture, and creating new organisations. To undermine opponents, they capture or undermine opponents' organisations, prevent the creation of opponent organisations, and 'raise the heat' around the issue to reduce the number of opponents. These will be dealt with (necessarily briefly) in turn.

First, incumbents have, in response to rising public concern around climate change, reinforced and reoriented existing organisations. The best example of this would be the BCAs Environmental Task Force, set up to defend coordinated industry responses to the potential threat of the 'ecologically sustainable development' policy process.

Industry groups are never unitary; as the climate issue rose, different actors saw business opportunities. Therefore, fossil fuel incumbents' second strategy has been to prevent organisations being reconfigured or captured by 'the enemy within'. Two examples merit recounting. The first involves a move by the Australian Gas Association (AGA), which saw that gas would be a lower carbon electricity fuel than coal. It made noises within the BCA and AIGN. The head of the Minerals Council took the AGA CEO aside and said:

> you know you pursue this hardline and you scratch the coal industry too much harder and they will come out and we will start talking about nitrous oxide emissions, methane emissions, or pipe leakages—you know there is a lot of health issues around burning gas particularly in these unflued burners in Victoria which contributes a lot… we know this is your Achilles' heel—don't do it—because if you do it we'll have a big brawl between the energy industries in this country in the public arena which won't do anybody any good. (Pearse, 2005: 125)

Shortly after, another powerful actor tried to reshape BCA policy. The new chief executive of mining giant BHP called a meeting to discuss possible greenhouse policies. He recalled:

> I held a party and nobody came. They sent some low-level people that almost read from things that had been given to them by their lawyers. Things like, Our company does not acknowledge that carbon dioxide is an issue and, if it is, we're not the cause of it and we wouldn't admit to it anyway. (Wilkinson, 2007)

Ultimately the BCA announced it had no position on ratification of the Kyoto Protocol. Its 2006 move to support carbon pricing forced John Howard's hand, but since then it has vacillated.

The third incumbent strategy has been to create new organisations, which have had one or more of three functions. These are firstly to co-ordinate policy responses (AIGN), secondly to present an emollient face to the public and policymakers (e.g. the short-lived Sustainable Development Australia and the longer-lasting Australian Minerals and Energy and Environment Foundation), and thirdly to 'take the fight to the enemy'; such groups include the neo-liberal think tank the Tasman Institute (1990–1997), the Australian Trade and Industry Alliance, and Manufacturing Australia, and groups such as the climate-change-denying radical flank, such as the Lavoisier Group, founded in 2000 with the support of senior mining industry figures.

Incumbents mobilise to reduce their opponents' capacity to act, seeking to capture or undermine existing organisations which are a real or potential threat. This is a well-established tactic. Interviewed in 1993, famed environmental activist Milo Dunphy noted that in the early 1970s the Australian Conservation Foundation's council included not only high-ranking public servants but also "*several mining company executives who… were there 'on a brief to keep this emerging conservation movement under control'*" (Hutton and Connors, 1999: 135). More recently, in 2009 a journalist, Paddy Manning, noted that the Clean Energy Council, which had formed from a merger of the Business Council of Sustainable Energy and the Australian Wind Energy Association got about 10% of its annual revenues from companies with investments in coal-fired power. He quoted a Green Senator as saying the Council was "completely ineffective" as an advocate for renewable energy and had not even advocated for a higher emissions reduction target (Manning, 2009).

Beyond this, incumbents have successfully prevented the creation of new (business) lobby groups. In 2001 Environment Minister Robert Hill, along with business allies, tried to form an Australian branch of the Pew Centre on Global Climate Change. The then head of the MCA found out that sponsored meetings were taking place. One of Pearse's informants recalls:

> And Dick Wells was basically chairing the AIGN at the stage and he said 'hey, what is this about? We are not being invited to any of these forums. You are paying for it out of Commonwealth funds. I mean what is the story? Don't we have this open process?' In the end, business people who AIGN knew very well and AIGN briefed on these things went along to these meetings anyway and told them that they saw no benefit in it so it fell over. (Pearse, 2005: 353)

Five years would pass before any climate grouping involving business gained any traction.

Finally, simply 'raising the heat' around an issue can have the benefit of dissuading some actors from taking part in a debate.[2] For example, in 2011 The Australian newspaper misrepresented the position of a large Australian bank (Westpac) over its carbon policy stance. Westpac, which in 2008 had urged Rudd to keep the CPRS compensation to a minimum (Irvine, 2008), and other previously loud groups, such as Ai Group, were largely silent during the heightened period. Ai Group had tried to 'subcontract' its support for ETS to an international consultancy. The consultancy showed the Opposition drafts of its work. The response was extremely vehement, and the consultancy, fearful of its future relationships with the Coalition, watered down its findings to meaninglessness (Mildenerger, 2015).

6 Economic Strategies

This section discusses the actions incumbents took to shape the economic conditions within which they faced challenges from competitors. Incumbents have worked to defend profits by keeping environmental regulations as loose as possible and defeating a 2010 proposed mining tax. In addition, they have striven to slow the growth of alternative sources of electricity generation, while supporting the expansion of fossil fuel infrastructure and shaping the NEM to suit the needs of centralised fossil-fuel generators.

In May 2010 Kevin Rudd, fresh from retreating on the ETS, attempted to introduce a Mining Tax. The mining industry response was prompt and ferocious. In just six weeks, it spent AU$22m on an extensive advertising campaign, under the heading 'Keep Mining Strong' (Murray et al., 2016). When Rudd was overthrown by his deputy, Julia Gillard, the tax proposal was watered down. Rio Tinto's CEO commented that "*policymakers around the world can learn a lesson when considering a new tax to plug a revenue gap, or play to local politics*" (Albanese, 2010).

State support for fossil fuels is nothing new. As early as 1983 Lowe noted that the National Energy Research Development and Demonstration Council was heavily favouring fossil energy projects (Lowe, 1983). This trend has continued. The 2004 Energy White Paper *Securing Australia's Future*, avoided support for renewables and supported fossil fuels, extolled the virtues of car-

[2] This is not to say that attempts at 'silencing' do not occur at a more strategic/logistical level. For an exploration of the Howard government's attitude to civil society, see Hamilton and Maddison (2007).

bon capture and storage (see Baker, 2005a, b for an account of how industry had lobbied). Carbon Capture and Storage would become the signature technological solution proposed by Kevin Rudd, who used taxpayer funds to create the Global Carbon Capture and Storage Institute (Pearse et al., 2013; Taylor, 2012). Meanwhile, support for renewable energy generation has been relentlessly attacked, with policies constantly reviewed and revised, leading to investment droughts (Effendi and Courvisanos, 2012; Parkinson, 2015).

Three other points relating to the electricity grid are worth noting. Firstly, incumbents stand accused of having deliberately and consistently overestimated future electricity demand to build state-funded infrastructure, so-called 'gold-plating' of the electricity grid (Hill, 2014). Secondly, the institutional arrangements for the NEM have side-lined environmental concerns (Diesendorf, 1996) and favoured incumbents. On the latter point, the former head of the Energy Users Association of Australia likened putting the states' energy ministers in charge of a separate new body, the Australian Energy Market Commission as "like putting Dracula in charge of the blood bank" (Hill, 2014). Regulatory gaming of the NEM has continued, with decisions which would favour renewable energy generation (especially community-owned) repeatedly deferred. Meanwhile, researchers argue that the NEM's opacity, exacerbated by current federal policy "*puts the power into the hands of large incumbents, who will actually use tenders to get their own costs down, but they won't necessarily pass on the savings to* [consumers]" (Vorrath, 2017).

Finally, fossil fuel incumbents are also lobbying intensively for state funding of new fossil fuel infrastructure—in the form of coal-fired power stations and a railway from prospective coal fields to the Queensland coast.

7 Cultural Strategies

Incumbent industries routinely engage in ongoing maintenance of their public image, via sponsorship of indisputably 'good' actions (sponsorship of air ambulances, etc.). They also have responded to climate change by engaging in issue minimisation and outright denial, as well as 'issue shifting.' To do this they have created think tanks and front groups to provide a steady stream of (mis)information for journalists and cultural warriors. They have attacked renewable energy for its purported aesthetic and wildlife impacts. For over a decade they have claimed that wind turbines are a health risk to human beings. Beyond this, they have reified "baseload," asserting that only centralised fossil-fuel generators can provide "energy security". Most recently they have tried to reframe events such as the 2016 South Australian blackout as a reason to abandon renewables (Hudson, 2017b). These are discussed in turn.

For many years mining industry groups have run extensive campaigns highlighting mining's contribution to the economy, and to the Australian 'way of life'. Esso ran an 'Energy for Australia' advertising campaign in the late 70s and early 1980s, associating itself with iconic Australian scenes (James, 1983). In 1991–1992, the Australian Mining Industry Council, moving on from its previous slogan mining as "the backbone of the country," told Australians that mining was 'Absolutely Essential.' In 2007 the NSW Minerals Council ran a similar campaign 'Life: Brought to you by mining.' More recently MCA launched 'Mining. This is our Story' in 2011 and 'Australians for Coal' in 2014. Alongside this, industry groups burnish their credentials through the sponsorship of sports clubs, rescue helicopters and the like (Pearse et al., 2013; Cleary, 2011). Possible technological responses to coal's climate impact have been front and centre of two television campaigns—'NewGenCoal' in 2008 and 2015's 'Little Black Rock' (Hudson, 2015a).

7.1 Issue Minimisation and Attacking the Messenger

Minimising an issue—declaring that it is overstated or a hypothetical threat, and only of interest to a few (self-interested and/or malevolent) scientists and activists—is a time-honoured tactic. After writing the book *Silent Spring* Rachel Carson was accused of trying to sabotage the American food production industry. One food industry figure said: "*I thought she was a spinster… What's she so worried about genetics for?*" (Hutton and Connors, 1999: 96). In response to calls to abandon a proposed dam that would flood the Franklin River, Tasmanian Premier Robin Gray declared it "*grossly over-rated… For eleven months of the year the Franklin is nothing but a brown ditch, leech ridden, unattractive to the majority of people*" (Lines, 2006: 201). Descriptions of climate change as 'only a theory,' 'overblown' or a 'green religion' are legion. Incumbents regularly state that climate change is a minor, manageable and disputed problem, and deride those concerned about it as addicted to apocalypse for psychological and/or financial reasons, out-of-touch elitists at best, and potentially dupes of foreign powers or knowingly treasonous.

7.2 Outright Denial

Outright denial of climate change has long been considered by most industry incumbents to be a high-risk and unnecessary, strategy. They deliberately avoided it in 1994/5 for fear that they would lose credibility with policymakers and motivate environmentalists. However, other groupings were bolder, including the now defunct Tasman Institute, which hosted various skeptical scientists on tours in the early 1990s. After its demise, the baton was picked up by the Lavoisier Group, formed in 2000 (Taylor, 2000), when it seemed that Australia might adopt a domestic ETS. Lavoisier was bankrolled in part by mining magnate Hugh Morgan, who has since the 1970s been a staunch advocate of mining and opponent of environmentalism, feminism and other 'anti-progress' isms. Lavoisier, which economist John Quiggin (2001) described as "*devoted to the proposition that basic principles of physics* […] *cease to apply when they come into conflict with the interests of the Australian coal industry*" has held conferences and run opinion pieces in newspapers denying the need for action. It even turned the emails stolen from University of East Anglia (the so-called 'climategate' emails) into a glossy book.

More mainstream, and better funded, the Institute of Public Affairs (IPA) has been a consistent, loud and effective voice against climate mitigation for almost thirty years. Closely linked to the Liberal Party, it published its first article on the costs of climate change (based on CRA's modelling report) in 1989. Since then it has run a steady stream of articles, opinion pieces and appearances that shift between casting doubt on climate science and predicting enormous negative consequences from mitigation policies, setting up groups with names like the Australian Environment Foundation and the Australian Climate Science Coalition (McKewon, 2012). It has helped organise tours by speakers opposed to climate action and has organised the publication of various books titled Climate Change: The Facts (with 2010, 2014 and 2017 editions).

The IPA has had a significant political impact. According to the former head of the AIGN John Daley, it became increasingly influential around 2006 and while it "conducted very poor analysis" was:

> very influential in the public debate… IPA picked up a lot of what was going on in the United States regarding climate change and brought it to Australia. They were especially effective in persuading a chunk of the Liberal Party that climate change was something they should ignore. (cited in Sharova, 2015: 76, emphasis added)

7.3 Specific Policy Contestation

The fossil fuel industry has run three climate-policy-related advertising campaigns. In February 1995 a coordinated flurry of newspaper adverts, timed to coincide with two policy roundtables, highlighted the potential costs of a carbon tax. In late 2009 the *Australian Coal Association* produced the relatively emollient 'Let's Cut Emissions, Not Jobs' campaign, especially targeting marginal constituencies in Queensland and New South Wales and featuring a doleful white male coal miner. In 2011, after the success of the 'Keep Mining Strong' campaign, and with usual lobbying methods ineffectual, the MCA and others launched an advertising blitz under the banner of the Australian Trade and Industry Alliance (ATIA). MCAs Sidney Marris, before his move to Prime Minister Turnbull's office told another researcher:

> We called it a Trade Alliance because our consensus was that the policy is penalizing exporters. So, it included us and the Australian Chamber of Commerce and Industry, who were most involved in the campaigning. *Other organizations were involved as well but we weren't close with them. We were the most active*. (Sharova, 2015: 76, emphasis added)

ATIA claimed that Gillard's ETS would be "*world's highest carbon tax*". Its numbers were contested (Sartor, 2011), but it persisted.

More recently, the proposed National Energy Guarantee of 2017–2018 saw the creation of the so-called Monash Forum, which aimed to attack renewables and put government-support for more investment in coal-fired plants on the policy agenda (Hudson, 2019).

7.4 Issue Shifting

Issue minimisation and denial are both risky strategies potentially causing more debate and environmental activism. A safer option is to shift discussion to economic consequences for the Australian economy and individuals. This was done effectively during the 1994/5 carbon tax battle and has continued to be used.

Further, an ambit claim that extracting coal is a moral good (or duty) has been made by several leading Australian politicians. In April 2014, the largest US coal miner, Peabody, announced an advertising campaign called Advanced Energy for Life, which aimed to "*Build Awareness and Support to End World's Number One Human and Environmental Crisis*" of Global Energy Poverty. Six months later, while opening a $3.9 billion coal mine, then Prime Minister Tony Abbott said: "*Coal is good for humanity, coal is good for prosperity, coal is an essential part of our economic future, here in Australia, and right around the world…*" (ABC, 2014).

Two years later, after environment minister Greg Hunt had argued that not selling coal to India would be an act of neo-colonialism (Taylor, 2015), Malcolm Turnbull echoed this sentiment, declaring "*Coal is going to be an important part of our energy mix, there is no question about that, for many, many, many decades to come, on any view*" (Murphy, 2016).

These efforts to 'wedge' opponents of coal-mining as anti-progress and anti-poor people reached a peak on February 9th 2017. During a heatwave, Treasurer Scott Morrison entered Parliament for question time, clutching a lump of coal. Supplied by the MCA, it had been lacquered so it would not smudge the hands of those who held it. Morrison gave an extraordinary speech, which demands quoting at length:

> This is coal. Do not be afraid. Do not be scared. It will not hurt you. It is coal. It was dug up by men and women who work and live in the electorates of those who sit opposite—from the Hunter Valley, as the member for Hunter would know. It is coal that has ensured for over 100 years that Australia has enjoyed an energy-competitive advantage that has delivered prosperity to Australian businesses and has ensured that Australian industry has been able to remain competitive in a global market. Those opposite have an ideological, pathological fear of coal. There is no word for 'coalophobia' officially, but that is the malady that afflicts those opposite. It is that malady that is affecting the jobs in the towns and the industries and, indeed, in this country because of the pathological, ideological opposition to coal being an important part of our sustainable and more certain energy future.
>
> Affordable energy is what Australian businesses need to remain competitive. They cannot fizzle out in the dark as those opposite would have them do, as businesses in South Australia are now confronting. On this side of the House, you will not find a fear of coal any more than you will find a fear of wind—except for that which comes from the Leader of the Opposition; you will not find a fear of sun; you will not find a fear of wave energy; you will not find a fear of any of these sources of energy. What you will find is a passion for the jobs of Australians who work for businesses that depend on energy security that those opposite want to switch off, just like the South Australian Labor government is switching off jobs, switching off lights and switching off air conditioners and forcing Australian families to boil in the dark as a result of their Dark Ages policies. (Morrison, 2017)

This framing echoed that of various groups, especially during the heated year of 2011 when 'no carbon tax' rallies, called by radio shock-jocks, were held, and a "convoy of no confidence" travelled to Canberra to pillory Gillard's policies, especially carbon pricing. Wear (2014) argues this was not an example of 'astroturf'—corporate-funded efforts mimicking 'grassroots'—while pro-carbon tax activists claim that the organiser of the convoy told them it was funded by ATIA (Peterson, 2011).

The IPA, and individuals such as mining magnate Gina Rinehart, have also sponsored speaking tours by prominent sceptics, notably Lord Monckton in 2010 and 2011. One problem was that these people lack specific institutional affiliations (or academic credentials altogether). The Abbott government tried to solve this by inviting Danish statistician Bjorn Lomborg to head an academic institute. Students at various universities blocked this (ABC, 2015).

Incumbents have also attempted to reduce pro-climate groups' capacity to act. In 2014 the MCA tried to argue that divestment campaigns pressuring banks to withdraw from funding fossil fuel projects were a form of illegal secondary boycott (Davidson, 2014). Meanwhile, following MCA lobbying, the Federal government has instigated inquiries into environmental groups' funding. However, MCA has recently had to soft-pedal on this, as one of its largest contributing members, BHP, has expressed disquiet about the reputational risks of being seen to be silencing democratic protest (Remeikis, 2018). Meanwhile, in 2015 the Abbott government de-funded the Environmental Defenders Office (Arup, 2013).

More specifically, there has been a concerted campaign against renewable energy, especially wind, on the grounds of health (so-called 'wind turbine syndrome' see Chapman and Crichton, 2017), and wildlife impacts (Hudson, 2017a). More generally, proponents of renewables are derided as elitist, middle-class and out of touch with 'real' Australia. An endless torrent of economic modelling, recycled through the opinion columns by industry figures and anti-renewables politicians, is used to 'prove' that renewables are, and always will be, too expensive (see Parkinson, 2017a) Newscorp, owned by Rupert Murdoch, is the primary purveyor of this. The term 'baseload' has been promulgated endlessly as a reason to keep centralised fossil-fuel generators in play, despite critique of the concept (Diesendorf, 2007).[3] Alongside this, incumbents used the September 2016 South Australian blackout to argue for centralised fossil fuel generation, despite the cause—cyclonic winds bringing down 22 transmission cables—being unrelated to South Australia's rapid increase in renewable energy generation (Lucas, 2017; Holmes, 2016).

8 What Next for Australia and Decarbonisation?

In this section I speculate on the activities incumbents may undertake in the future. At time of writing Australia still has a Federal government opposed to strong climate action. Given that pressures for decarbonisation are escalating, and the price of renewable generation and both grid-scale and domestic

[3] The Chinese State Grid's R&D chief Huang Han dismissing coal's claim to be an indispensable source of "base load" generation (Parkinson, 2016).

energy storage dropping, splits may emerge between those who expect to prosper through innovation and diversification and those who are wedded—economically, technologically, psychologically—to threatened assets.

8.1 Political

Incumbents will seek to dilute policy. For instance, AIGN has lobbied so that Australian companies can buy cheap overseas emissions ‘reductions’ credits. In its submission to the 2017 climate policy review, it argued: “A competitive, credible, and liquid market is necessary to ensure the success, efficiency and effectiveness of an emissions reduction policy. This should include credible local units, as well as access to credible international markets/units” (Federal Government, 2017: 43). This seems to have been accepted. If Labor forms a government, a battle will occur over an Emissions Intensity Scheme (EIS), currently Labor policy. Greens’ climate spokesman Adam Bandt notes: “*The EIS is becoming more and more popular among business and polluters precisely because they have looked at the details and realised that while it might push coal out, it won’t bring renewables in*” (Parkinson, 2017b).[4] To that end, incumbents presumably are preparing for a change in government by identifying lobbyists with personal relationships to senior Labor figures who can secure meetings so policies can be modified to suit the needs of (especially) the gas industry, which has more allies than it did 20 years ago.

Industry may seek to exploit state-federal tensions. It will also have their own tensions to manage, between coal and gas. These are exemplified by the gas company AGL’s unwillingness to bend to Federal Government demands to extend the life of an ageing, unreliable and ever-more-expensive coal-fired plant in NSW. AGL, it should be noted, left the MCA in 2016.

One point of agreement may be support for the proposed ‘Snowy Hydro 2.0’, by which water could be used as an energy storage mechanism. Such a scheme could be an incumbent-stabilising technological development within the grid, extending the life of fossil fuel generation, while providing a patina of ‘green-ness’.

Incumbents can be expected to continue using the legal system to chill dissent. Indian scholar and author Amitav Ghosh notes that: “*American intelligence services have already made the surveillance of environmentalists and climate activists a top priority*” (Ghosh, 2017: 140). He asks: “*How will the security*

[4] Parkinson (2017b) notes: “*The Greens distrust the EIS because it was originally dreamed up by the fossil fuel lobby and is considered a Trojan horse for the gas industry*”.

establishments of the West respond to these threat perceptions? In all likelihood they will resort to the strategy that Christian Parenti calls the "politics of the armed lifeboat"", a posture that combines "*preparations for open-ended counter-insurgency, militarized borders*, [and] *aggressive anti-immigrant policing*" (Ghosh, 2017: 143).

Corporate-funded spies have already been exposed in anti-coal groups (Laird, 2015). Meanwhile, in New South Wales, anti-protest laws have become more draconian. de Kretser (2016) notes that:

> The NSW laws give police excessive new powers to stop, search and detain protesters and seize property as well as to shut down peaceful protests that obstruct traffic. They expand the offence of "interfering" with a mine, which carries a penalty of up to seven years' jail, to cover coal seam gas exploration and extraction sites.

Environmentalism is already being framed as 'radicalism' and 'extremism' in Federal government 'Radicalisation Awareness Kit' supplied to schools (Jabour, 2015).

Meanwhile, Tienhaara (2017) suggests that fossil fuel corporations will adopt tobacco industry tactics and use investor-state dispute settlements "*to induce cross-border regulatory chill: the delay in policy uptake in jurisdictions outside the jurisdiction in which the ISDS* [Investor-State Dispute Settlement] *claim is brought*". She makes the point that these corporations "*do not have to win any ISDS cases for this strategy to be effective; they only have to be willing to launch them*".

8.2 Economic

The economic interests of Australian fossil fuel industry—extractors, transmitters and distributors—are beginning to diverge. As noted above, fossil fuel (primarily coal) incumbents devoted a large amount of time to enforcing industry unity. They may continue to try, but the potential costs are rising, with the risk of defection by companies such as BHP and Rio Tinto. Ominously, both are divesting from coal (Biesheuvel, 2017; Yeomans, 2017; Gray, 2018). We may begin to see investors shift away from thermal coal assets, while metallurgical coal, needed for the production of steel, remains relatively strong. Internationally, Australian governments have historically sought to defend and extend the interests of coal companies. This is unlikely to change, regardless of which party is in power.

As assets decrease in value we may see intensification of use—trying to extract value while any still exists—even if this accelerates decline. In any case, as mines close or face closure, incumbents will probably attempt to socialise the cost of mine-site remediation, while continuing to fight health-based claims for compensation.

Meanwhile, those who own gas-fired plants, transmission networks and retailing face a different set of challenges. To paraphrase Mark Twain, reports of the utility 'death spiral' may be greatly exaggerated (see Costello and Hemphill, 2014 for an historical overview). However, as Newbury (2016) notes there are many challenges around:

> the continuity of the existing technological regime; the emergence of cost competitive technologies; competitive intensity; ongoing natural monopoly status of electricity network utilities; consumer empowerment; business models and economies of scale; long term investment decision making; demand trends; emergence and diffusion of new technologies; emergence/impact of battery storage; and long-term industry attractiveness.

As rooftop solar and domestic storage penetration increases, problems of load defection, if not actual grid defection, may intensify (Schneider Electric Blog, 2015). Some incumbents, seeking to extract maximum rents, will attempt to defend existing rules via the regulatory framework, to gold-plate the infrastructure, and lock in customers with long contracts where possible. Others, presumably, will seek to reinvent themselves as energy services providers (Price Waterhouse Coopers, 2014). New entrants will proliferate, followed by a winnowing. While there will be business model innovation, it is hard to see incumbents engaging in defensive technological innovation. That ship has sailed.

8.3 Culturally

An intense culture war over climate change has raged for a decade. That war will end one day, but further bloody battles are likely. It is hard to see how Liberals and Nationals, who have asserted that climate change is not real, are going to get themselves out of the corner they have painted themselves into. If and when renewables become the cheapest option, they may be able to adopt a 'homo economicus' stance.

Fossil fuel lobbies will engage in more intense advertising campaigns, perhaps around their internal sustainability programmes (Wright and Nyberg, 2017). These may happen not because there is compelling evidence that they work, but simply because such campaigns provide emotional and psychological side-benefits. Marchand (1987) notes of pre-war American campaigns: "*Of uncertain efficacy in other respects, they provided their sponsors the significant and undeniable satisfactions of enhancing their self-esteem and winning the respect of their peers*" (see also Hudson, 2015a).

While companies like AGL reposition themselves as 'low carbon' (Agl.com.au, 2018), coal interests face a dilemma. Their campaigns against disruptors are leading to reputational risk for less-committed members of their business lobbies, while their last two 'pro-coal' campaigns (2014 and 2015) were met with derision. Pro-coal incumbents may choose to burnish their own credibility using more general 'Aussie battler' mythology, harking back to the 'Backbone of the country' adverts of the 1970s, with adverts showing 'hard-working real Aussies' (as per 2009's 'Let's Cut Emissions Not Jobs' campaign). A second line of attack might be to emphasis mining's contribution to Australia's balance of payments position, though this would be risky given ongoing questions over mining's tax payments (as distinct from royalties). Such a campaign might also invoke 'baseload' 'energy security' and 'reliability' in an attempt to reinforce existing 'common sense' views of a masculinised and centralised system of power (generation), alongside ongoing economic modelling claiming that the costs of renewable energy are enormous.

There will be continuing attempts to blame all problems with the existing electricity grid (around price, reliability, etc.) on renewable energy. Teething problems will be painted as existential threats, with the inevitable distortions, corruption and hype within renewables and storage amplified to tarnish the 'brand'. Proponents of renewables, and opponents of cheap international credits, will continue to be attacked as effete elitists, extremists and purists and 'un-Australian'[5] uninterested in the problems of 'normal people'.

9 Conclusion

Hindsight bias will make it 'obvious' what happened to Australia. If it is a picture of decay and ever-increasing economic, cultural and psychological damage as the impacts of climate change overwhelm efforts at mitigation and adaptation, then future scholars will be able to point to the successful incumbent defenses over the last thirty years, and the frailty of efforts to disrupt

[5] In the 1920s, Thomas Griffith Taylor, an Australian scientist saw his textbook which described parts of Western Australia as 'arid', banned. In the 1960s, opponents of a Japanese exploratory oil rig off the Great Barrier reef were accused of "*tools of American oil companies who were trying to exclude Japanese business from the lucrative reef oilfields*" (Hutton and Connors, 1999: 104).

their power. Conversely, if Australia adopts renewables, and becomes a renewable energy superpower, then scholars will point to the plummeting cost of renewables, their uptake by householders and communities, and the efforts of companies and social movement actors to speed the transition to a low-carbon future. For the time being, then, Australia sits on the edge of both major directions of travel; concrete predictions have become a fearful proposition given that Australian climate politics is effectively 'off the map'.

Without the benefit of hindsight, it is not possible to say if the political class will find the knowledge, courage and capacity to act that has so far eluded it. While the ALP is benefitting from complete disarray within the Coalition at present, if it—as expected—forms the next government, it will probably come under sustained pressure to move beyond its relatively mild eco-modernist positions. Vested interests will not give up without a fight. We can expect new front groups, new arguments, renewed attempts to transfer costs of remediation and decommissioning onto the taxpayer.

History matters. Past policy battles and settlements shape and constrain future possible courses of action. Writing before climate change became an issue, Australian academic Stephen Boyden (1987: 30) noted, "*lack of motivation, even active resistance on the part of the corporate organisations which hold power in society can effectively block useful cultural adaptive responses*". As this chapter has shown, for thirty years, Australian incumbents in business and the state have fought successful campaigns against both the pricing of carbon and support for renewables. Academics, activists and 'ordinary citizens' would be well-served by understanding better the repertoires deployed by these actors in their efforts to defend their positions, since the past is a guide (albeit imperfect) to the future.

References

ABC. 2004. Leaked Documents Reveal Fossil Fuel Influence in White Paper. *ABC*, September 7. http://www.abc.net.au/pm/content/2004/s1194166.htm.

ABC. 2014. Coal 'Good for Humanity' Prime Minister Tony Abbott Says at $3.9b Queensland Mine Opening. *ABC*, October 13. http://www.abc.net.au/news/2014-10-13/coal-is-good-for-humanity-pm-tony-abbott-says/5810244.

ABC. 2015. UWA Cancels Contract for Consensus Centre Involving Controversial Academic Bjorn Lomborg. *ABC*, May 8. http://www.abc.net.au/news/2015-05-08/bjorn-lomborg-uwa-consensus-centre-contract-cancelled/6456708.

Agl.com.au. 2018. AGL Updates its Brand for the Future. *AGL*. https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2017/april/agl-updates-its-brand-for-the-future.

Albanese, T. 2010. Mining Issues, A Global View. Presentation at Melbourne Mining Club, July 8. https://republicofmining.com/2010/07/09/rio-tinto-ceo-tom-albanese-london-speech-mining-issues-a-global-view/.

Anon, 1957. Ocean Could Swamp Cities. *Sydney Morning Herald*, April 8, p. 1.

Arup, T. 2013. Abbott Government Strips Environmental Legal Centres of Federal Funding. *Sydney Morning Herald*, December 17.

Avelino, F. 2017. Power in Sustainability Transitions: Analysing Power and (dis) empowerment in Transformative Change Towards Sustainability. *Environmental Policy and Governance* 27(6): 505–520.

Baker, R. 2005a. Burying the Problem. *The Age*, July 30. http://www.theage.com.au/news/national/burying-the-problem/2005/07/29/1122144018763.html.

Baker, R. 2005b. How Big Energy Won the Climate Battle. *The Age*, July 30. http://www.theage.com.au/news/national/how-big-energy-won-the-climate-battle/2005/07/29/1122144020224.html.

Behm, A. 2015. *No, Minister: So You Want to Be a Chief of Staff?* Melbourne: Melbourne University Press.

Biesheuvel, T. 2017. One of the World's Biggest Miners is About to Go Coal-free. *Bloomberg*, November 10. https://www.bloomberg.com/news/articles/2017-11-10/one-of-the-world-s-biggest-miners-is-about-to-go-coal-free.

Boyden, S. 1987. *Western Civilisation in Biological Perspective*. Oxford: Clarendon Press.

Chapman, S. and Crichton, F. (2017) *Wind Turbine Syndrome: A Communicated Disease*. Sydney: Sydney University Press.

Chubb, P. 2014. *Power Failure: The Inside Story of Climate Politics Under Rudd and Gillard*. Melbourne: Black Inc.

Cleary, P. 2011. *Too Much Luck: The Mining Boom and Australia's Future*. Melbourne: Black Inc.

Combet, G. 2015. *The Fights of My Life*. Melbourne: Melbourne University Press.

Costello, K. and Hemphill, R. 2014. Electric Utilities' 'Death Spiral': Hyperbole or Reality? *The Electricity Journal* 27(10): 7–26.

Davidson, S. 2014. *A Critique of the Coal Divestment Campaign*. Canberra: Minerals Council of Australia.

de Kretser, H. 2016. NSW Anti-protest Laws Are Part of a Corrosive National Trend. *Sydney Morning Herald*, March 22. http://www.smh.com.au/comment/nsw-anti-protest-laws-are-part-of-a-corrosive-national-trend-20160321-gno10h.html.

Denniss, R. 2015. Spreadsheets of Power: How Economic Modelling Is Used to Circumvent Democracy and Shut Down Debate. *The Monthly*, April. https://www.themonthly.com.au/issue/2015/april/1427806800/richard-denniss/spreadsheets-power.

Diesendorf, M. 1996. How Can a "Competitive" Market for Electricity be Made Compatible with the Reduction of Greenhouse Gas Emissions? *Ecological Economics* 17 (1): 33–48.

Diesendorf, M. 1998. Australian Economic Models of Greenhouse Abatement. *Environmental Science & Policy* 1 (1): 1–12.

Diesendorf, M. 2007. The Baseload Fallacy. ANZSEE Solar 2007 Conference, Alice Springs. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.397.8606&rep=rep1&type=pdf.

Effendi, P. and Courvisanos, J. 2012. Political Aspects of Innovation: Examining Renewable Energy in Australia. *Renewable Energy* 38(1): 245–252.

Federal Government. 2017. *Review of Climate Change Policies*. Canberra.

Garnaut, R. 2008. Oiling the Squeaks. *Sydney Morning Herald*, December 20.

Gelbspan, R. 1998. *The Heat Is on: The Climate Crisis, the Cover-Up, the Prescription*, Updated ed. Boston: Perseus Books Group.

Gelbspan, R. 2004. *Boiling Point: How Politicians, Big Oil and Coal, Journalists and Activists Are Fueling the Climate Crisis—And What We Can Do to Avert Disaster*. New York: Basic Books.

Ghosh, A. 2017. *The Great Derangement: Climate Change and the Unthinkable*. Chicago: University of Chicago Press.

Gillard, J. 2014. *My Story*. Sydney: Random House.

Goodell, J. 2007. *Big Coal: The Dirty Secret Behind America's Energy Future*. New York: Houghton Mifflin.

Gough, I. 2017. *Heat, Greed and Human Need: Climate Change, Capitalism and Sustainable Wellbeing*. London: Edward Elgar.

Gray, D. 2018. Rio Sells Key Coal Assets to Glencore for $2.2bn. *Sydney Morning Herald*, March 20.

Hamilton, C. 2001. *Running from the Storm: The development of Climate Change Policy in Australia*. Sydney: UNSW Press.

Hamilton, C. 2007. *Scorcher: The Dirty Politics of Climate Change*. Melbourne: Black Inc.

Hamilton, C. and Maddison, S. 2007. *Silencing Dissent: How the Australian Government Is Controlling Public Opinion and Stifling Debate*. Crows Nest, NSW: Allen & Unwin.

Hill, J. 2014. Power Corrupts. *The Monthly*, July. https://www.themonthly.com.au/issue/2014/july/1404136800/jess-hill/power-corrupts.

Hogarth, M. 2007. *The 3rd Degree*. North Melbourne, VIC: Pluto Press Australia.

Holmes, D. 2016. 'We Must Keep the Lights on': How a Cyclone was Used to Attack Renewables. *The Conversation*, October 3. https://theconversation.com/we-must-keep-the-lights-on-how-a-cyclone-was-used-to-attack-renewables-66371.

Hudson, M. 2015a. Hashtags v Bashtags: A Brief History of Mining Advertisements (and Their Backlashes). *The Conversation*, September 14. https://theconversation.com/hashtags-v-bashtags-a-brief-history-of-mining-advertisements-and-their-backlashes-47359.

Hudson, M. 2015b. Carbon Coups: From Hawke to Abbott, Climate Policy is Never Far Away When Leaders Come a Cropper. *The Conversation*, September 15. https://theconversation.com/carbon-coups-from-hawke-to-abbott-climate-policy-is-never-far-away-when-leaders-come-a-cropper-47542.

Hudson, M. 2017a. Wind Beneath Their Contempt: Why Australian Policymakers Oppose Solar and Wind Energy. *Energy Research & Social Science* 28 (June): 11–16.

Hudson, M. 2017b. A Year Since the SA Blackout, Who's Winning the High-wattage Power Play? *The Conversation*, September 28. https://theconversation.com/a-year-since-the-sa-blackout-whos-winning-the-high-wattage-power-play-84416.

Hudson, M. 2017c. It's 30 Years Since Scientists First Warned of Climate Threats to Australia. *The Conversation*, November 30. https://theconversation.com/its-30-years-since-scientists-first-warned-of-climate-threats-to-australia-88314.

Hudson, M. 2019. What Does Canute want? The "Monash Forum" and the Australian Climate Deadlock. *Energy Research & Social Science* 49: 126–133.

Hutton, D. and Connors, L. 1999. *History of the Australian Environment Movement*. Cambridge: Cambridge University Press.

Irvine, J. 2008. Bank Breaks Ranks on Emissions. *Sydney Morning Herald*, September 15, p. 3.

Jabour, B. 2015. Radicalisation Kit Links Activism and Alternative Music Scene to Extremism. *The Guardian*, September 25. https://www.theguardian.com/australia-news/2015/sep/25/radicalisation-kit-links-activism-and-alternative-music-scene-to-extremism.

James, P. 1983. Australia in the Corporate Image: A New Nationalism. *Arena* 63: 65–106.

Jenkins, K. Sovacool, B. and McCauley, D. 2018. Humanizing Sociotechnical Transitions Through Energy Justice: An Ethical Framework for Global Transformative Change. *Energy Policy* 117: 66–74.

Johnstone, P. and Newell, P. 2018. Sustainability Transitions and the State. *Environmental Innovation and Societal Transitions* 27: 72–82.

Kaptein, E. 1993. Neo-liberalism and the Dismantling of Corporatism in Australia. In: Overbeek, H (Ed.) *Restructuring Hegemony in the Global Political Economy: The Rise of Transnational Neo-liberalism in the 1980s*. London: Routledge, pp. 79–109.

Keane, B. 2012. The Heady Rise of Mining Donations. *The Australian*, August 22.

Kelly, P. 2014. *Triumph and Demise: The Broken Promise of a Labor Generation*. Melbourne: Melbourne University Press.

Laird, P. 2015. Maules Creek Spies Just the Latest Example of the Coal Industry's Underhand Tactics. *Sydney Morning Herald*, June 5.

Legget, J. 1999. *The Carbon War: Global Warming and the End of the Oil Era*. London: Penguin.

Lines, W. 2006. *Patriots: Defending Australia's Natural Heritage*. St Lucia: University of Queensland Press.

Lowe, I. 1983. Who Benefits from Australian Energy Research? *Science and Public Policy* 10(6): 278–284.

Lucas, A. 2017. Confected Conflict in the Wake of the South Australian Blackout: Diversionary Strategies and Policy Failure in Australia's Energy Sector. *Energy Research & Social Science* 29: 149–159.

Manning, P. 2009. The Fox in the Hot House. *Sydney Morning Herald*, August 15. http://www.smh.com.au/business/the-fox-in-the-hot-house-20090814-el4k.html.

Manning, P. 2014. Fox Guarding the Hen House? State Government Revenues Raise Regulatory Questions. *Crikey*, September 18. https://www.crikey.com.au/2014/09/18/fox-guarding-the-hen-house-state-government-revenues-raise-regulatory-questions/

Marchand, R. 1987. The Fitful Career of Advocacy Advertising: Political Protection, Client Cultivation, and Corporate Morale. *California Management Review* 29(2): 128–156.

Marks, R.E, Swan, P.L., Dixon, P.B., Johnson, D.T., McLennan, P. and Schodde R. 1989. *The Feasibility and Implications for Australia of the Adoption of the Toronto Proposal for Carbon Dioxide Emissions*. Report to CRA Ltd, 1989.

McCright, A. and Dunlap, R. 2010. Anti-reflexivity: The American Conservative Movement's Success in Undermining Climate Science and Policy. *Theory, Culture and Society* 27(2–3): 100–133.

McKewon, E. 2012. Talking Points Ammo. The Use of Neoliberal Think Tank Fantasy Themes to Delegitimise Scientific Knowledge of Climate Change in Australian Newspapers. *Journalism Studies* 13(2): 277–297.

Mildenerger, M. 2015. Fiddling While the World Burns: The Double Representation of Carbon Polluters in Comparative Climate Policymaking, PhD Thesis, Yale University.

Mitchell, A. 2012. Lobbying for the Dark Side. *Meanjin* 712, Winter 2012: 39–54.

Morrison, S. 2017. *Hansard Display, Parliament of Australia*. https://www.aph.gov.au/Parliamentary_Business/Hansard/Hansard_Display?bid=chamber/hansardr/e5ff85d2-b96e-4e0e-8227-2131e40beaf7/&sid=0150.

Murphy, K. 2016. Coal Will be Important 'For Many, Many Decades to Come', Says Turnbull. *The Guardian*, October 25. https://www.theguardian.com/environment/2016/oct/25/coal-will-be-important-for-many-many-decades-to-come-says-turnbull.

Murray, J. Nyberg, D. and Rogers, J. 2016. Corporate Political Activity Through Constituency Stitching: Intertextually Aligning a Phantom Community. *Organisation* 23 (6): 908–931.

Newbury, P. R. 2016. Technological Change and the Evolution of Sectoral Systems of Innovation in Highly Regulated Industries: A Study of the Australian Electricity Industry, PhD Thesis, School of Business, The University of Queensland. https://doi.org/10.14264/uql.2016.153.

Oreskes N. and Conway, E. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. London: Bloomsbury.

Parkinson, G. 2015. Renewable Investment Drought to Continue as Utilities Extend Buyers' Strike. *Reneweconomy*, August 31. http://reneweconomy.com.au/renewable-investment-drought-to-continue-as-utilities-extend-buyers-strike-28325/.

Parkinson, G. 2016. Base Load Power a Myth Used to Defend the Fossil Fuel Industry. *Reneweconomy*, May 4. http://reneweconomy.com.au/base-load-power-a-myth-used-to-defend-the-fossil-fuel-industry-96007/.

Parkinson, G. 2017a. Finkel Modelling Ignores New Technologies, Cheaper Renewables? *Reneweconomy*, June 14. http://reneweconomy.com.au/finkel-modelling-ignores-new-technologies-cheaper-renewables-33626/.

Parkinson, G. 2017b. If Renewables Target Is Met This Year, What's Next for Wind and Solar? *Reneweconomy*, May 4. http://reneweconomy.com.au/if-renewables-target-is-met-this-year-whats-next-for-wind-and-solar-65994/.

Pearse, G. 2005. The Business Response to Climate Change: Case Studies of Australian Interest Groups, Unpublished PhD Thesis, Australian National University.

Pearse, G. 2007. *High & Dry*. Camberwell, VIC: Penguin Group (Australia).

Pearse, R. 2018. *Pricing Carbon in Australia Contestation, the State and Market Failure*. Routledge.

Pearse, G., McKnight, D. and Burton, B. 2013. *Big Coal: Australia's Dirtiest Habit*. Sydney: UNSW Press.

Peterson, M. 2011. Counter-protests Make a Point. *Canberra Times*, August 22, p. 2.

Price Waterhouse Coopers. 2014. Future Utility Business Models. https://www.pwc.com/gx/en/utilities/publications/assets/pwc-future-utility-business-models.pdf.

Priest, M. 2013. Climate of Chaos. *Australian Financial Review*, April 27, p. 42.

Quiggin, J. 2001. Wishful Thinking of Walsh's True Believers. *Australian Financial Review*, April 11.

Raworth, K. 2017. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. London: Random House.

Remeikis, A. 2018. Minerals Council of Australia Kicks Off Coal Power Campaign Despite BHP Threat. *The Guardian*, January 10. https://www.theguardian.com/environment/2018/jan/11/minerals-council-of-australia-kicks-off-coal-power-campaign-despite-bhp-threat.

Rootes, C. 2008. The First Climate Change Election? The Australian General Election of 24 November 2007. *Environmental Politics* 17(3): 473–480.

Sartor, O. 2011. To dear Trade and Industry Alliance. *Daily Telegraph*, August 16. https://www.dailytelegraph.com.au/trade-and-industry-alliance-should-be-brought-to-book-for-false-advertising/news-story/40ac685da719308200baa854a34ccb74?sv=ea68f66156a909943750f392b8c6323f.

Schneider Electric Blog. 2015. A Vaccine Against the Utility Death Spiral. *Schneider Electric Blog*. https://blog.schneider-electric.com/utilities/2015/09/24/a-vaccine-against-the-utility-death-spiral/.

Sharova, N. 2015. Australia's Flirtation with Climate Policy: Role of Industry Groups, Environmental NGOs, Think Tanks, and Public Opinion, Masters Thesis, University of Wyoming.

Slezak, M. 2017. Turnbull's New Climate and Energy Adviser Worked for Coal Industry Lobby Group. https://www.theguardian.com/australia-news/2017/feb/03/turnbulls-new-energy-adviser-worked-for-coal-industry-lobby-group.

Taylor, L. 2000. Businessmen Throw Stones at Greenhouse. *Australian Financial Review*, April 11, p. 4.

Taylor, L. 2012. Coal hard light of day for dud scheme. *Sydney Morning Herald*, June 17. https://www.smh.com.au/politics/federal/coal-hard-light-of-day-for-dud-scheme-20120616-20gog.html.

Taylor, L. 2015. Australia Approved Coalmine Because it Isn't a Neo-colonialist Power, Greg Hunt Claims. *The Guardian*, December 2. https://www.theguardian.com/environment/2015/dec/02/australia-approved-coalmine-because-it-isnt-a-neo-colonialist-power-greg-hunt-claims.

Taylor, M. 2014. *What Australia Knew and Buried…Then Framed a New Reality for the Public*. Canberra. ANU Press.

Tienhaara, K. 2017. Regulatory Chill in a Warming World: The Threat to Climate Policy Posed by Investor-State Dispute Settlement. *Transnational Environmental Law*: pp. 1–22. https://doi.org/10.1017/S2047102517000309

Vorrath, S. 2017. Consumers Miss Out on Renewables Benefits as Big 3 Pocket Profits. *Reneweconomy*, December 8. http://reneweconomy.com.au/consumers-miss-out-on-renewables-benefits-as-big-3-pocket-profits-33191/.

Wear, R. 2014. Astroturf and populism in Australia: The Convoy of No Confidence. *Australian Journal of Political Science* 49 (1): 54–67.

Wilkinson, M. 2007. Delayed Reaction. *Sydney Morning Herald*, March 24. http://www.smh.com.au/news/environment/delayed-reaction/2007/03/23/1174597882759.html?page=fullpage#contentSwap3.

Wright, C. and Nyberg, D. 2017. How Bold Corporate Change Goals Deteriorate Over Time. *Harvard Business Review*, November 22.

Yeomans, J. 2017. South32 Backs Out of Coal with South African Exit. *Daily Telegraph*, November 27. http://www.telegraph.co.uk/business/2017/11/27/south32-backs-coal-south-african-exit/.

9

Buffeted or Energized? India's Dynamic Energy Transition

Daniel Gilbert and Pooja Chatterjee

1 Introduction

India is booming economically. Speaking in January 2018, Indian PM Narendra Modi set a target for the size of the economy to double in just seven years, by 2025 (Rachman, 2018).

As India's economy grows, so does its appetite for energy. Writing in November 2017, Tim Buckley and Kashish Shah of the Institute for Energy Economics and Financial Affairs predicted the same time horizon for the doubling of India's GDP announced by Modi three months later and forecast that electricity demand would '*nearly double*' over the same time period too (Buckley and Shah, 2017: 6); the difference being accounted for in a (moderate) reduction of Indian energy intensity. Achieving reductions in energy intensity are easier to promise than actually deliver as the following figures for 2017 indicate, when, according to a joint report of the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA) India experienced "*electricity demand growth of over 12% (or 180 TWh)*, (which) *outpaced the 7% growth in* (overall) *economic activity*" (OECD/IEA, 2018: 11).

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Significant drivers of this growth in energy demand include: export-led economic growth; urbanisation; the wealth effects of India's growing middle class; and increases in the overall population reach of the nation's regional electricity grids—targeted by the Government of India (GoI) to reach all Indian homes, all of the time, by 2022 (IEA, 2017a: 46). Alongside mandating increased power supply, the GoI is also targeting the achievement of a reduction in at least one third in India's greenhouse gas (GHG) energy emissions, as compared to a 2005 baseline, by 2030 (IEA, 2017a: 46); the seriousness of this target is underscored by GoI policies in support of a (steady) Indian clean energy transition, in particular from coal to renewable sources.

These are ambitious "green" targets for India, albeit many caveats apply—caveats that amount to far more than quibbling, not least with respect to thermal coal consumption. The instincts of the "old" post-war and post-Independence India would, surely, be as they ever were: to solely concentrate on increasing power generation, and not to dilute that focus through concessions made to *international* environmental concerns—noting that the domestic concern of protecting Indian forestry from coal mining (*inter alia*) incursion has long been a matter of GoI policy, for instance as articulated by National Forest Policy of 1988, published by the country's Ministry of Environment and Forests (MoEF 1988). One thing that has not changed, however, is the dichotomy between international and national environmental impact: the choking impact of Indian coal-origin air pollution is felt primarily in-country; the GoI policy response against yet more-and-more thermal power reliance can be seen, admittedly, in the context of GHG and global climate change responsibility, but also in light of Indians' need to breathe tolerably clean air.

According to Abraham Maslow's Theory of Human Motivation (Maslow, 1943: 370), a precondition of humans prioritising our higher needs (from safety right up to '*self-actualization*'), is that we first fulfill the fundamental physiological needs, such as the need for food, clothing and shelter. This mirrors the traditional GoI focus on Indian human development needs over anything else. But those old policy assumptions are no longer reliable, perhaps even tenable.

The critical analysis of the salient and diverse (inter)national drivers for Indian power sector consumption, not least regarding price of generation regardless of source, and the emerging rebalancing of thermal/renewable power generation that is increasingly apparent, is key to making informed forward projections even in the sense of conditions-as-they-are, *ceteris paribus*, and also in the context of different possible future global scenarios.

For instance, the answers to questions such as 'Is GoI policy change primarily driven by a preference for clean and sustainable energy as a good thing in its own right; or is India's clean energy transition driven by more by economic self-interest?' imply different outcomes should economic comparative advantage "switchback" to coal in the future, as it did in during the first half of the 1980s globally due to significant increases in the price of competitor fuels oil and gas (i.e. petroleum), or as a result of increasingly urgent, critical and immediate climate change concern. In scenario planning, it is important to allow for more cynical interpretations too, e.g. that the GoI, in its policy-making, is making a virtue out of economic opportunity and necessity combined, rather than pursuing green energy transition policies for any reasons of altruism; indeed, and whether or not that is in fact true, such balanced thinking provides an antidote to the often fawning international coverage of GoI energy policies—acclamation that avoids the awkward fact of massive ongoing thermal power production in the country. After all, "*coal is not an obsession for India, it's a compulsion*" (quoting Harjeet Singh, a New Delhi-based international climate policy manager for international NGO *ActionAid*) (Adler, 2015).

At the time of writing, in 2018, India's position is encouraging regardless of (evolving) motivation: it is clear that, and irrespective of ultimate cause, altruism and economic self-interest are increasingly aligned in India when it comes to clean energy. Long has the reverse been the case; the sea change has come about through the fast emergence of a dynamic and highly competitive renewable energy (RE) sector in India. Unlike India's previous renewable energy champion of its early years of Independence, the now firmly eclipsed hydroelectric sector, this time its solar that is lighting up the way, both literally and figuratively.

But this Chapter is not primarily about Indian renewable energy. Rather, it takes that sector as an exogenous development, one of huge significance that is the subject of current and ongoing research by other, specialist, authors and institutes. Exogenous to what?: exogenous to coal.

The 'long goodbye' to Indian coal is the focus of this Chapter, the justification for which are manifold, notably that: it remains the incumbent, dominant, primary energy source in India; the duration and speed of that 'goodbye' is highly uncertain, and with it India's energy transition; its governance travails are such that they may not be limited to its own confines and could afflict the renewable energy sector too; and that without it pushed aside and crowded out, renewable energy will remain, for all its gloss and policy appeal, at the comparative sidelines.

A final reason is that it is now so unfashionable a topic that it has become markedly under-studied and researched compared not just to solar energy, but indeed to petroleum in its many forms, nuclear, biofuels, wind and pretty much any other form of primary energy source. We hope to at least partly redress that balance in this Chapter; love it or hate it, coal matters, and energy transitions, in common with transitions in general, result from a mix of both push and pull factors.

India's energy transition pitches solar energy against, and alongside, coal—the hydrocarbon primary source of energy that is the scourge of climate science, but which still dominates Indian electricity generation as the nation's one primary energy source. This Chapter asks: is India's energy transition, in headline terms from coal to solar energy, likely to be buffeted or energised given current horizons and knowledge? It asks that question by examining this Chapter's endogenous locale: coal in India, its mining, import and combustion. Having done so, it then considers the following proposition: 'Advent of the Sun King', i.e. the eclipse of Indian coal by Indian solar energy, in particular, and renewables, in general. Importantly, critical analysis of that proposition is firmly rooted in the conclusions reached regarding the incumbent monarch, since if the foundations of that reign were not so uncertain then surely Indian renewable energy development would indeed have been buffeted not energised.

Section 2, below, considers the *status quo ante*, namely the ongoing dominant position within India's energy (electricity) sector; Sect. 3 references the concept of a paradigm shift and how it may be applicable to the subject at hand; Sects. 4 and 5 consider 'push' factors weakening coal's Indian energy primacy sector, and putting it under threat of competitive substitution; subsequent sections are titled: International Push Factor: India and Climate Change Politics (Sect. 6); Coal Threat: Review of Domestic and International Push Factors (Sect. 7); and then, lastly, the Conclusions (Sect. 8).

Simply for reasons of space, considerations of 'clean coal' technologies, and how they might impact on India's energy transition, are explicitly out-with the scope of this chapter is; instead these factors are suggested as topics of future research.

2 An Incumbent Enthroned: King Coal

In the Indian Supreme Court coal block allocations ruling *Manohar Lal Sharma v The Principal Secretary & Ors*. (Indian Supreme Court, 2012: 1), the apex court reckoned: "*Coal is king and paramount Lord of industry is an old saying in the industrial world… In India, coal is the most important indigenous energy resource and remains the dominant fuel for power generation and many industrial applications… It is no exaggeration that coal is regarded by many as the black diamond*."

The (British) East India Company commenced Indian coal mining in 1774 at the Ranjigang coalfield, located along the western bank of river Damodar in the modern state of West Bengal. Looking forward nearly two-and-a-half centuries to 2018, this coalfield is still worked, but now by Eastern Coalfields Limited, a subsidiary of Coal India Limited (CIL), India's national coal-mining company. Large-scale coal mining in India has been undertaken throughout this long time period, even as the British Raj in Indian came (1858) and went (1947), forming an integral part of the India's economy.

According to the Central Electricity Authority (CEA, 2018a: 1), nearly two-thirds of the installed capacity of Indian power stations are accounted for by thermal power generation, as of January 2018. In more detail: of 334.40 GW total installed capacity, coal accounted for a majority (57.96%) of the total, at 193.82 GW (2018a: 1). Critically, coal's 58% of installed capacity translates into 76% of actual power generation (Shahi, 2018).

The past historic trend is for more and more coal-burning nationally. India's estimated total consumption of raw coal by industry increased from 462.35 MT during 2006–2007 to 832.46 MMT during 2015–2016 and consumption of brown coal/lignite increased from 30.81 MMT in 2006–2007 to 42.52 MT in 2015–2016 (Financial Express, 2017: 41). India's greatest consumption of raw coal is by its electricity generation sector, followed by steel industries. Industry-wise estimates of consumption of coal shows that during 2015–2016, electricity generating units consumed 508.25 MT of coal, followed by steel and (coal) washery industries (56.45 MT), cement industries (8.93 MT) and sponge iron industries (7.76 MT) (Financial Express, 2017: 41). According to the CEA, as on January 31, 2018, thermal power projects, with a capacity of 64,861.15 MW, were under construction in the country (CEA, 2018b: 23), adding yet more coal burning capacity.

In the context of Indian energy, coal has long reigned, and continues to reign. When and who will call time on this monarchy?

3 The Dynamics of a Paradigm Shift: India's Energy Transition

The concept of a paradigm shift is well established, as theorised by Thomas Kuhn (Kuhn, 1996). For Kuhn (1996: 5–6), paradigms are ways of interpreting the world and dominant paradigms for any particular topic are the norm, occur in periods of '*normal science*' during which understanding is collectively refined through new empirical experimentation and discovery, and articulated on the implicit or explicit assumption of the ongoing, underlying, paradigm being correct. Paradigms, however, are not immune to attack by evidence that undermines them, albeit they are often resilient for a period of time even after, rationally, there is no objective basis for them to retain their primacy. Whereas the exogenous 'pull' for an Indian energy transition (here: considered as a paradigm shift), can be identified as a mix of (perhaps) climate change politics and (certainly) the low-cost competitiveness, dynamism, and growth of India's renewable energy sector, the 'push' factor is a composite of wicked problems endogenous to India's coal sector, at the pithead, import terminal and thermal power station.

Section 4, below, begins an enquiry into these push factors domestically; and Sect. 5 considers a key international push factor: Indian and climate change politics.

4 King Coal, Vulnerability Begins at Home

Sometimes it is not just charity that 'begins at home'. Indeed, there are a number of longstanding weaknesses of coal's position in the Indian marketplace, both with regards to coal mining and to thermal power generation. These are outlined below in this Sect. 4.

4.1 Indian Coal Quality

An important dynamic in GoI policy-making is an inherent weakness in 'king' coal's armour—and one of the primary reasons why coal is imported into India in the first place, one that is quality-related. Indeed, not only has India suffered historically from shortages of domestically mined coal in absolute terms, there is also a quality deficit too: generally Indian coal is of low calorific value, contains relatively high levels of ash content (i.e. the remaining non-combusted constituents of the coal, post-thermal power generation), reducing both its efficiency on combustion and also the attendant levels of air pollution—Indians are all too often 'short of breath', just as CIL could be said to be 'short (of) tons'. That available foreign imported coal is of higher quality, with regards to (lower) ash content, is of little benefit to coal's overall popularity given that foreign imports are thereby highlighted as superior to domestic production. One important environmental positive for Indian coal quality, compared to many imported coal sources, is that it is comparatively low in sulfur content.

The dirtiest and lowest calorific value coal, and hence the most inefficient to burn, is brown coal, also known as lignite. Lignite is mined in both southern India, especially the state of Tamil Nadu, and in the north, in particular in Gujarat. It is primarily used by the electricity generation sector, which accounts for 90% of consumption, and its total use by that industry and others (e.g. cement) is increasing, notably from just 31 MMT in 2006–2007 up by nearly 40% to 43 MMT in 2015–2016 (Ministry of Statistics and Programme Implementation, 2017: 41). However, the poor quality of Indian coal is not limited to its lignite: Indian 'hard' coal is of comparatively dirty and of low calorific value too.

Indian coal can and is 'washed' to improve its quality, both in terms of the removal of ash/other debris and in order to increase its calorific value per tonne by between 10 and 20% (NITI Aayog, 2017a: 100). This is achieved through the use of coal washeries. If washing takes place prior to transportation then there is an added benefit of a reduction in tonnage to be shifted, for the same overall calorific value of coal; a reduction in ash content also reduces fouling/slagging deposits on power station boiler surfaces, deposits which in turn reduce the efficiency of thermal power production.

Seeking positive action on coal ash content, India's Three-Year Action Agenda (NITI Aayog, 2017a: 100), 2017/8 to 2019/20 calls for "*15 new Coal Washeries, including 6 Coking Coal washeries with a capacity of 18.60 MTPA and 9 non-coking Coal washeries with a capacity of 94 (MMT per annum to) be commissioned to meet Ministry of Environment, Forest and Climate Change guidelines*". Levels of coal washing demand are likely to increase significantly if the GoI implements the 2015 recommendation of its environment ministry's Expert Appraisal Committee allowing for coal with an ash content of up to 25% to be imported, more than doubling the ceiling of 12% set in 2013 (Cornot-Gandolphe, 2016: 14). However, implementation could be challenging and goes beyond simple regulatory promulgation; speaking in February 2018, N. Gautam noted that coal washeries in India were only operating at 50% capacity and that high-ash content coal being, burnt "*raw* (untreated)… *on some pretext or another*", and a resulting failure of Indian thermal power sector ("*and that by very proper good companies*") to consistently meet the 1997 requirement that "*all power plants located in sensitive areas, metropolitan cities and in areas distant from the coalfields, must use coal with less than 34% ash* [content]" (Mathur et al., 2003: 319). Moreover, the question of washing high ash content coal is complicated yet further by policy contestation centered on national content aspirations relating to those washeries themselves, for example Venugopal et al. (2016: 196) lament that "*the existing situation of Indian coal washing Industry is a resultant of gross negligence of the industries to strengthen R&D for development of indigenous technologies*". In an argument that combines a call for greater national content with a scientific rationale supporting such a policy outcome, Venugopal et al. (2016: 196) argue that, "*indigenous technology designed for difficult washing characteristics of Indian Coal be used, instead of foreign coal washing technology… with little or no modification*". Hence it is the contention of Venugopal, Patel and Bhar that coal washeries in India operate at suboptimal levels not just due to underutilisation but also as a result of technological issues too.

Whilst cost-control is an incentive for power companies for non-compliance of coal washeries, regular water shortages in coal and thermal power rich states such as Bihar is an inhibiting factor in capacity utilisation for what is a very water-hungry process (insert reference). Indeed, not only are washeries major consumers of water, the Indian experience is that they can and do, when poorly managed, lead to significant groundwater pollution, providing an additional compelling human health reason to transition away from coal. The figures regarding air pollution, specifically, are appalling in their human toll: Dockery and Evans (Dockery and Evans, 2017: 1863) report a range of 0.94 to 1.25 million early deaths in India in 2015 that were attributable to air pollution (central estimate: 1.09 million), much of it produced by coal-fired power. Coal washing and coal blending, namely of domestic high ash content coal with lower ash content imports, has the same, State regulated, aim of reducing overall ash content of combusted coal, in particular for reasons of human health and wider environmental protection. Even so, air pollution reduction and environmental safeguarding of groundwater remain highly salient political issues in India—not least, as is discussed below, adherence to the applicable regulations is less than complete; together, they constitute important twin environmental drivers in favour of a cleaner energy transition.

4.2 Indian Coal Importation, Exploration, Transportation & Production

Indian coal, or rather coal in India since much of it is non-Indian in origin, faces an additional broad range of challenges due to its relatively low quality, as measured by an unwelcome combination of low calorific value and high ash content. The sector continues to experience significant travails unrelated to the quality of its output, these range from shortcomings in exploration, production and transportation, and the necessity of coal imports to complement domestic production for purposes of achieving necessary coal quantity, not just overall blended quality.

Indeed, one nuance to the concept of "Indian king coal" is that, like so many monarchies, it is of mixed national origins. During the financial year 2015/2016, India mined 536.5 MMT of coal (NITI Aayog, 2017a: 99), and for 2016 as a whole it was ranked by the IEA as the world's second largest producer (IEA, 2017b: 17); however, such is India's demand for the mineral that it is also a very significant coal importer—over the same time period, India imported a further 200 MMT of the mineral (Dogra, 2016). This reliance on coal imports has the effect of providing a further chink in the armour of King Coal in an Indian context since: many of the coal mining jobs India's thermal power sector support are not, in fact, Indian; India is exposed to foreign pricing/coal availability risk; and the coal trade has a negative net impact on the nation's balance of trade. Travails and related weakness to King Coal's reign in India also relates to exploration, transportation and production; see below.

Exploration and production of Indian coal has often failed to keep pace with GoI expectations and targets, resulting in well publicised shortcomings to, admittedly very high and perhaps unrealistic, GoI expectations. This failure in expectations management provides a further weakness in King Coal's position within the Indian polity.

With respect to coal exploration, in 2013 Greenpeace (2013: 13) warned that "*at targeted growth rates, CIL's extractable coal reserves could be exhausted within 17 years*" leading to enhanced levels of coal imports, noting that "*reserve levels as of April 2011, (were) at 16% below (the) levels cited in… documents of 2010*"; noting, by way of explanation, that CIL's '*exploration efforts*' were falling short (and by 65%) of its targets, and that if CIL could improve its performance in this respect then future supply shortages could be avoided. CIL performance in this regard did subsequently improve, success that can be observed in an annual increase, despite ongoing extraction, of more than 7

Billion Metric Tonnes (BMT) to 302 BMT in total estimated coal reserves of as of 1.4.14 (Ministry of Coal, 2014: 1). As of April 01, 2017, India's officially estimated reserves of coal, as reported by the Press Information Bureau (PIB), had increased yet further, to over 315 BMT (PIB, 2018).

Nor has GoI's push for CIL to make new discoveries has abated since; India's Three Year Action Agenda (NITI Aayog, 2017a: 99), specifically calls for: exploration of a quarter "*of the untapped 5,100 sq km balance coal bearing area to ensure availability of more coal mining blocks*"; and conversion of a quarter "*of the 139.15 billion tonnes of coal reserves as on 31st March, 2016 in the 'Indicated' category into 'Proved' category by engaging top exploration companies with attractive contractual provisions*".

Just as exploration results are both impressive in absolute terms, but sometimes well below the stretching targets set by the GoI, such is also the case for CIL production. Current CIL production targets remain challenging, as per the Three-Year Action Agenda, 2017/8 to 2019/20: "*CIL has to raise its production from the current level of 536.5 MMTs in 2015–2016 to 1 BBT by 2019–2020*", albeit "*depending on coal demand*" (NITI Aayog, 2017b: 99). Whether or not this 81% increase in production is achievable is possible, but open to doubt; as illustrated by data for financial year 2017/2018 which shows a continuation of this pattern: total CIL production was up from the previous year, but only by 2.39%, to 567.37 MMT (Cuddihy, 2018), and therefore well short of its 600 MMT annual target for that year. Any ongoing failure by CIL to meet its production targets increases the likelihood of additional coal imports being required to meet demand; the other key variable, of course, being the actual level of aggregate demand for coal in India.

India's draft (2017) National Energy Policy (NEP) appears weak in its prediction (wish?) that increases in coal demand by the Indian power sector that it expects "*is likely to be first met by domestic coal*" (NITI Aayog, 2017b: 34), not least since the same document acknowledges that ensuring requisite increases in domestic supply "*will require quick exploitation of our reserves*" (2017b: 34). An obvious, but undesired by GoI policymakers, alternative scenario is that a substantial amount of any such supply gap is met through coal imports.

In fact, the commercial dynamics behind Indian coal imports are complex, combining coal quality, pricing and reliability of supply drivers, and interact with political, dynamics such as those laid bare in the form of demanding (in both senses) GoI targets for domestic coal production above. Both regarding the inherent risks of relying on large-scale coal imports (including from Indonesia, which has brought additional above ground risk), and with regards to other high-salience factors including the extreme and fatal levels of air pollution in India in very large part due to coal burning, the resilience of a dominant coal-fired thermal power sector in India may be undermined by its seeming inability to meet the twin challenges self-sufficiency in coal production and acceptably clean air for the public to breathe, further to combustion.

One such maximalist projection of imports was provided in 2014 by Rio Tinto, which forecast that Indian coal imports would more than double to approximately *c.*225 MMT by 2025, extrapolating from an observed (2007–2012) annual rate of increase of *c.*11 MMT p.a. from the base, 2007, figure of 25 MMT, and implying a *c.*800% increase over this 18 year time period (Rio Tinto, 2014, p. 34). Starting from the same base year of 2007, Chikkatur et al. (2007: 3745) suggests a more conservative rate of annual increase in thermal coal imports of 5.5%; over an 18 year period, compounded, this implies an overall 150% increase in coal imports by 2025. Whether the increase is 150%, 800%, or somewhere within this range, the level of increase is highly significant and substantial—and a challenge to India's prospective energy transition towards clean and sustainable energy.

Additionally, there is the question of the cost of these imports, and their (financial, as opposed to human) price. The higher cost of foreign imports was implicitly accepted by large-scale, power sector, consumers of foreign coal who collectively built an extensive thermal fleet in littoral locations close to coal terminal ports; these locations saved time and money by limiting to the minimum onshore transportation, reducing the impact of the price differential to domestically mined coal, and provided additional benefits in terms of both supply quality and reliability. However, the choice to rely so heavily on imports, in particular from Indonesia led to the introduction of an additional, exogenous, above ground risk.

Indonesian coal price changes were an important catalyst in the evolution of India's coal governance, as explored below in the context of the GoI's 'SHAKTI' scheme. Alongside Indonesian imports, India has also relied, in particular, on South African and Australian coal too. The situation is highly dynamic between these suppliers. Traditionally Indonesian coal has dominated Indian thermal coal imports; this was the case even after the Government of Indonesia introduced regulatory changes in 2010 that led to increased export prices for the nation's coal. Indonesian coal has the benefit of both low sulfur and ash content (typically below 15% ash, compared to up to 50% for Indian coal), but unfortunately it is also low in calorific value too—a looming vulnerability yet to be fully exploited in FY 2014, when Indonesia retained a 78% market share of Indian thermal coal imports (Cornot-Gandolphe, 2016: 13). However, and presaging an ongoing trend away from Indonesian coal imports, the following year saw a significant drop in international prices for thermal coal, in particular for higher grades, hence "*higher-grade coal therefore became more competitive than Indonesian low-rank coal*" and imports of thermal coal above the calorific value 5,831 kcal/kg "*jumped from 5 Mt in FY2014 to 18.7 Mt in FY2015*" crowding out Indonesian imports as Australian imports doubled in a single year and those from South Africa increased by 54% (Cornot-Gandolphe, 2016: 13).

India's Three-Year Action Agenda of 2017 calls for this momentum in coal import diversification to be maintained, alongside a reduction in overall levels of imports: "*it is important that India increases its domestic coal production to provide energy security and reduce its dependence on imports. The energy security may be further enhanced through diversification of the import sources*" (NITI Aayog, 2017a: 99). In the same year, 2017, India's Energy Minister, Piyush Goyal noted recent successes already achieved in reducing coal imports, including a 25% reduction year on year as of the previous December, and stated that he "*aims to eliminate coal dependency in the next few years*" (Goyal, 2017), a succinct statement of the same policy.

India's Three-Year Action Agenda (NITI Aayog, 2017a) emphasises energy security alongside the policy imperative of crowding out imports in favor of national content. Indeed, energy security remains a challenge for India. Despite all attempts to reduce any holdups in coal supply, coal supply shortages continue to afflict the power sector—this time born out of logistical constraints rather than production impediments. There is an ongoing need to improve Indian port coal capacity, as specifically identified in 2014: "*Indian ports cannot take capsize vessels which carry more cargo (can get only panamax freight: which are smaller and expensive) and reduce the cost. Moreover the average time taken by ships to load/unload at India ports is almost 96 hours, 10 times longer than in Hong Kong*" (Bose, 2014). India has responded with sustained and at-scale port investment, including the $123bn, GoI, '*Sagarmala Programme*' which, spread across 415 different projects, aims to develop new ports, modernise existing ones, increase port connectivity and industrial linkages, and provide support to local community development (Invest India, 2018).

Even when the coal has reached India, transportation of coal over long distance is proving to be a bottleneck and "…*coal stocks at operational thermal power plants have remained low at only 10 days of requirement. Importantly, the number of plants with critical-level coal stock has zoomed to 28 as of March 2018, with distant plants in western and northern India witnessing greater shortage*" (IIFL, 2018). In response, the GoI and CIL have proposed significant investment in rail freight infrastructure, including both new railway lines, not least a dedicated eastern freight corridor to be in service as of 2021, and improvements to existing lines (IIFL, 2018).

However, such railway investment does not address the constraining factor of cross-subsidy that coal freight in Indian is burdened with: Indian Railway (IR)'s 'explicitly over-prices coal freight by about 31 per cent to offset its 'social obligation' or coaching losses', amounting to an "*'overcharge' from coal… in FY 2017*" of approximately 108bn INR, comprising "*over 85 per cent of costs for transporting coal to thermal power plants*" or, on average, an extra 0.21 INR/kWh of cost rising up to threefold "*for power plants in distant states, which inherently rely on railways for coal*" (Kamboj and Tongia, 2018: 9). That this business model will be hard to break is evident from a quick review of, FY 2017, statistics: 60% of coal consumed in India was transported by rail, indicating a high degree of dependency on IR by the sector; and 44% of IR's revenues are derived from coal freight, and an even greater proportion of its profitability (2018: 9), completing a circle of coal sector-IR interdependency.

5 Indian Coal (Mis)Governance

A further weakness to the pre-eminence in Indian coal is its apparent widespread and longstanding mis-governance.

The World Bank defines '*governance*' as the "*manner through which power is exercised in the management of a country's economic and social resources for development*" (World Bank, 1992: 1). The United Nations Development Programme (UNDP) defines governance as "*the exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences*" (UNDP, 1997: 56).

In both these definitions, there is an emphasis on development and management of the country's affairs with good governance an enabling precursor, or 'hygiene factor'. In the context of private sector participation in the energy sector, public policy is not simply concerned with objective setting and management of resources, but also has a legitimate focus on ensuring good governance. In practical terms this includes that for-profit activity is not conducted at the expense of the public weal—in such circumstances there is a need to ensure (e.g. via laws, regulations and enforcement mechanisms) that, *inter alia*, consumers, the general public and the investors are all protected from oligopolistic profiteering and collusion, environmental pollution/public safety, and insider share dealing. If the assets are largely under the control/under the ownership of the State, the issue of governance is more direct since the State exerts controls, including directly as the beneficial owner. These concerns have led, in India, to an elevated level of alert, both up and downstream. Perceptions of suboptimal levels of governance combined with a degree of fatalism lead to low-bar targets of achieving 'good enough governance' that tolerates graft and mismanagement alike.

India's coal sector has proven highly problematic for successive GoIs to manage; many of the issues encountered are fundamentally ones of (mis)governance of the sector.

There is a longstanding and ongoing debate between whether mining (e.g. coal mining) is part of a global "resource curse" or whether the 'extractive industries' (*viz*. oil, gas and mining) are of developmental benefit to host countries; certainly, whilst India's history of economic development has been powered, primarily, by goal, the fact of a violent and illegal side to Indian coal mining (Bhattacharjee, 2017) speaks to a different, and more uncomfortable, truth. For instance, in the Dhanbad-Jharia coal basin of Jharkhand state boasts both a formalised coal mining sector and a mafia subculture linked to illegal mining, theft and trading that is linked to both corruption and a Maoist/'Naxalite' violent insurgency drawing economic rent from local, illegal, coal mining operations (Mukherjee and Choudhuri, 2013).

Illegality in Indian coal mining, which was not limited to Jharkhand, manifests itself in two ways: (i) illegal mining of the mines, typically small mines, mostly abandoned by the public sector companies when, for example, they have become uneconomical, and (ii) illegal marketing and distribution of the coal, scavenged from trucks, rail wagons, or even legal mines (Lahiri-Dutt, 2007). The mafia "*emerged as a quasi-outsourced economical and political department of the now centralised state-industry, becoming an intrinsic part of the mining regime during the 1970s to 1990s*"; by the 1990s, however, illegal coal mining/trading had assimilated even to the extent of being seen as '*normal business*' (Sanhati, 2011).

5.1 From Crisis, Comes Change

By mid-1991, change was coming, born of economic stagnation and crisis. India's currency crisis of the time was severe and the GoI sought loans from the International Monetary Fund and the World Bank. As a by-product of receiving such aid, sought to steadily liberalise the nation's economy, including privatisations of state assets, and the restructuring of assets retained under public ownership (Hiro, 2016). The coal-mining sector was not to escape untouched by this policy drive.

At the pithead, the first round of resulting structural changes in the coal industry were initiated through amendments to the applicable legal framework. In the context of coal shortages and electricity load shedding/power outages, the power sector was permitted as a designated, i.e. protected, end use for coal consumption, a legislative change effected by 1993 amendment to the Coal Mines (Nationalisation) Act (CMNA)1973; the cement gained the same benefit in 1996, through further legislative amendment (Ministry of Coal, 1993). These changes facilitated captive coal mining, i.e. extraction for consumption by a designated end user, by the private sector.

Downstream, India's Electricity Act of 2003 consolidated previous legislations governing electricity, and among other things and promoted competition in the power purchase costs, and efficiency in the provision of services. This was imperative given the poor financial health of the State Electricity Boards (SEBs). The coal-hungry SEBs, accountable for the supply of electricity to Indian consumers, both residential and industrial, had become "*bastions of political patronage rather than true business enterprises*" (Tongia, 2003: 6–7). The SEBs, at the time of writing, met the responsibilities of distribution and supply of power to the customers, but their massive and growing losses and frequent power thefts constrained their growth with state budgets being unable to cope up; "*in some states, SEBs had become the single largest drain on state finances and had eroded the states' ability to supply other social services such as health care and water infrastructure*" (Tongia, 2003: 7). Therefore, the measured reforms were intended to ease the pressure on the (i) coal industry by promoting captive mining by power generators and (ii) SEBs/distribution licensees by promoting competitive (potentially lower) prices to the end users.

However, the legacy issues in the coal industry also exposed a weakness within the GoI's governance and regulation of the power sector: a procurement driver for achieving value for money is that pursuit of low prices from power sector generators through competitive auction. However, this begs the question of what happens when the power generator fails to supply power at agreed low prices and instead seeks relief from its obligations; implying pass-on prices increases payable by the purchasing electricity distribution company (Discom), and finally, onto consumers. If the Discom refuses to pass through the increased cost, the project becomes unviable and 'stressed', or 'non-performing'—with knock on effects for the banking sector that provided the necessary finance. Management of this risk remains a governance challenge: the GoI's Scheme for Harnessing and Allocating Koyala (Coal) Transparently in India (SHAKTI) policy, discussed below, can be seen as a pragmatic policy response that is dressed up, as evidenced by the choice of name, as an accountability and transparency measure.

The introduction of the New Coal Distribution Policy (NCDP) in 2007 (Ministry of Coal, 2007) served as a major structural change in the coal industry; consolidated GoI policy and mandates on coal allocation, and remained an important point of reference, including through its regular GoI updating and amendment, for a decade after it was first issued. However, and as evidenced below, the structural changes between 1991 and 2010 did not eliminate the embedded arbitrariness, ambiguity and corruption, and human nature's inherent bias towards status quo.

5.2 Coal Mis-Governance Dénouement?: Coalgate and SHAKTI

In 2010 the GoI sought to steadily reform the coal sector in an evolutionary rather than a revolutionary manner, responding to the perception that the system of coal allocation, based on the concept of 'linkages' to the rest of the economy, led to arbitrary decision-making and needed to be opened up to more competition and transparency. The law governing the regulation of mines and developments of minerals—the Mines and Minerals (Development & Regulation) (MMDR) Act, 1957 (Ministry of Mines, 1957) was subsequently amended (in 2010 and again in 2015), to mandate the allocation of coal blocks by auction through the process of competitive bidding, e.g. see Ministry of Law and Justice (2015a).

This evolution approach to reform, whereby competition was allowed to coexist with previous forms of state-allocation, faced disruptive change with the breaking of the so-called 'Coalgate' scandal in 2012. The scandal's genesis was long-term mis-governance of the coal sector in India. Its spark was a 2012 report by the Comptroller and Auditor General (CAG) of India, specifically Report No. 7 of 2012–2013, Performance Audit of Allocation of Coal Blocks and Augmentation of Coal Production of the Ministry of Coal, also known as the 'CAG Report' (Comptroller and Auditor General of India, 2012). The report concluded (2012: 43–45) that there was a lack of transparency and objectivity in the allocation of coal blocks, recommended that the Indian Ministry of Coal should urgently consider remedial next steps, and made apparent to the Indian public how arbitrary previous the making coal allocations had often been prior to 2010. Further to national outcry, the scandal was popularly labeled as 'Coalgate' (Indian Express, 2017).

Responding to popular pressure, India's Central Bureau of Investigation initiating a probe into alleged corruption in the allocation of coal blocks. Coalgate also became the subject matter of a group of writ petitions filed in the nature of Public Interest Litigation, wherein it was alleged that these allocations were illegal and unconstitutional. Amongst many other commentators, former Ministry Coal Secretary P.C. Parakh was scathing in his criticism of the '*policy paralysis*' that he identified as being a key factor in its genesis, and is equally critical of the litigious outcome to the scandal: "*litigation will further delay production of coal from captive blocks and force the country to import more coal and add to inflationary pressures and worsen the already adverse trade balance*" (Parakh, 2014). The dénouement duly arrived in the same year of 2014 when the Supreme Court, in its order dated September 24 regarding *Manohar Lal Sharma v The Principal Secretary & Ors*. (Indian Supreme Court, 2012), cancelled 214 of 218 allocations made prior to 2010 and held that these allocations not only amounted to largesse, but were also both arbitrary and illegal.

Forced by circumstances and to minimise any impact on designated end use sectors (sponge iron, steel, cement and power utilities), the Government swiftly brought in ordinances and then legislation—the Coal Mines (Special Provisions) Act, 2015 (Ministry of Law and Justice, 2015b)—to allocate coal blocks (regarding these specified sectors) through either public auction or government allotment. Public opinion and pressure clearly favoured the former route. Through legislative reforms, which began in 2010 and continue at the time of writing, spurred on by practical difficulties that continue to affect the coal industry, the Government removed discretion in grant of mineral concessions and provided for all mineral concessions to now be granted only through auctions.

In many ways the catalyst for SHAKTI also occurred in 2010, the year when Indonesia's Ministry of Energy and Mineral Resources (MEMR) promulgated Regulation 17, 2010, which regulation (MEMR, 2010) had the effect of significantly elevating Indonesian coal export prices, to the extent that one author (Ghoshal, 2013) considered that in terms of "*Indian impact… may well be the end of the road for cheap Indonesian coal*." Responding to this price hike, Adani Power Limited (APL), and several other power generators reliant on Indonesian coal, requested that the regulator allow them to pass through their increased cost to consumers through higher prices. The Central Electricity Regulatory Commission, as regulator, and supported at appeal by the appellate tribunal for electricity, indeed allowed for a higher, compensatory tariff to be granted. But that decision was then challenged in the Indian Supreme Court, which apex court set aside the decisions of the regulators and held that the PPAs do not contain any clause that coal is to be procured only from Indonesia at a particular price and therefore, the price payable for the supply of coal is entirely for the risk-taking electricity generator to bear. The Supreme Court directed for any relief to be granted to the power generators to be restricted to the terms of the PPAs and the competitive bidding guidelines. The result was effectively an impasse and pushed many power projects to the brink of financial non-viability (Chatterjee, 2017).

The SHAKTI Policy was released barely a month later by the GoI; in May 2017, the GoI's Cabinet Committee on Economic Affairs approved the replacement of both the existing regime applicable to non-designated industrial coal sector consumers, and the NCDP-mandated arrangements applicable to designated sectors such as for electricity generation and based on coal linkages, with SHAKTI. The new policy had the effect of financially rescuing a wider range of non-performing thermal power plants—irrespective of whether there is a PPA or not or where PPAs have been signed based on supply of domestic coal or imported coal.

SHAKTI did more than bail-out struggling thermal power projects, it also presaged a major change in GoI coal mining policy aimed at delivering domestically mined coal reliably—in terms of both quality and quantity—affordably and on time to India's power sector, and hence avoiding the need for future measures to rescue that sector from the impacts of unexpected foreign coal price hikes. That change came ten months after SHAKTI's launch, in February 2018, when the Cabinet Committee on Economic Affairs, chaired by Prime Minister Narendra Modi approved the methodology for auction of coal mines/blocks for sale of coal under the Coal Mines (Special Provisions) Act, 2015 (Ministry of Law and Justice, 2015b) and the MMDR Amendment Act (Ministry of Law and Justice, 2015a). The following high salience changes resulting from these policy and legislative changes: (i) that there will be no restriction on the sale or utilisation of coal from the coal mine; and (ii) the end of the monopoly of the public sector competition and will encourage CIL and its subsidiaries to become more efficient and able to better compete in the energy marketplace (Cabinet Committee on Economic Affairs, 2018).

Regardless of this criticism, it is important to recognise that for some commentators, the GoI has now achieved its SHAKTI objective of ensuring transparency in coal allocation, for instance this is the view of S. K. Srivastava (Srivastava, 2018).

Whilst it is far too early to judge the efficacy of this policy change, and readers of this Chapter can make up their own minds regarding the efficacy of the SHAKTI scheme in terms of coal sector transparency, what can be concluded is that the mis-governance of India's coal sector has been publicly and cruelly exposed through, most recently, Coalgate and SHAKTI, and—over a longer time period—the mafia-rife illegal coal mining/theft taking place in peninsular northeast Indian as highlighted above with respect to the Dhanbad-Jharia coal basin. By exposing the need for fundamental reform of India's coal sector, both at pithead and thermal power station, these public failures of coal governance further undermine the pre-eminent position of King Coal in India, providing further space for an upstart pretender to dethrone the sitting (reigning) incumbent.

In sum, coal sector wider dynamics and of the coal and governance failings are, perhaps counter-intuitively, a significant driver in India's energy transition away from coal *in toto* and towards cleaner energy, in particular renewable energy; perhaps it is true that "*coal always curses the land in which it lies*" (Caudill, 1963: 37), certainly India is abundant with supporting evidence of this claim. Another political arena to test this veracity of any paradigm shift away from coal to renewables in India, and hence an energised rather than buffeted energy transition, is that of climate change politics and India' stance therein. Indeed, the domestic push factors providing febrile ground for any energy transition from coal to renewable energy in India do not, in fact, tell the whole story: international push factors are pertinent too.

Section 6, below, focuses on one such push factor that is of critical importance: India and international climate change politics.

6 International Push Factor: India and Climate Change Politics

Notably, one key political driver enabling India's reign by 'king coal' is the degree to which the sector was, previously, seemingly uninhibited by any domestic public policy concerns regarding global climate change. If coal is really to be left behind by India's paradigm-shifting energy transition, then India's positioning on climate change issues is a valid place to seek evidence either consistent or inconsistent with that hypothesis.

The impact of any evidence is likely to be non-symmetrical in the sense that an Indian climate change policy of denial or refusal to meaningfully engage in necessary GHG measures does not prove that India's energy transition will not take place anyway, for instance as a result of the comparative economic advantages of renewables over coal, whereas serious and binding commitments to tackle GHG emissions by the GoI surely do necessitate a significant and deep energy transition to sustainable primary sources and away from fossil fuels, if those commitments are credible.

Even in the former case, that is of denial/refusal to meaningfully engage in international climate change politics, that finding would be significant since it would suggest that any observed energy transition, e.g. from coal to renewable energy, was contingent on the vagaries of economics given an absence of demonstrated political commitment to significant GHG reductions. Of course, that commitment could emerge at a later date or alternatively the economics or renewables could continue to outdo those of coal, either way resulting in no stymieing (or 'buffeting') of India's clean energy transition but for different reasons. Or the opposite set of circumstances may occur, leading to a startling switchback to Indian coal-fired thermal power generation. Section 6.1 below starts the process of examining the available evidence.

6.1 The Salience of India's Climate Change Policy to the Nation's Energy Transition

Because of the scientifically-established link between coal-combustion, GHG emissions and anthropomorphic climate change, Indian policy on climate change has implications for its policy on domestic coal-consumption—until recently (see below) national policy decisions on climate change have been devised such that there has been no noticeable, substantive, inhibition on domestic coal fired power generation. However, presaging an important change of global and not just national significance, this is no longer the case—and the evolution of the GoI's climate change policy positions are of potentially highly significant to the nation's energy transition, and hence highly salient to any posited 'long goodbye' to fossil fuels in the country.

6.2 Climate Change Policy: Status Quo Ante

India's climate change policy, and its unbending restatement even in the face of international pressure to relent, was described as recently as 2009 as a "*salutary case study in the failure to build North/South trust*" in multilateral negotiations (Dubash, 2009: 1). As related by Mahr (2013), India "*has argued for years that developing economies should not be held to the same standards of reducing carbon emissions as developed countries, and that the imperative to develop and reduce poverty should trump India's committing to emissions targets*." No change, i.e. continuity, in terms of India's climate change policy evolution also meant, figuratively, the giving of 'no change' to anyone foolish enough to expect Indian policy concessions on its GHG emissions. India's position "*reflected a very traditional developing country position, tinged with neocolonial rhetoric*", the "*two most important and partly interrelated arguments behind (this) traditional Indian position (being) (a) the historic responsibility of the North and (b) per capita rights to global environmental resources*", according to Vihma (2011: 78). India's policy stance is significant not just in its own right, but in light of the fact of its "*leadership role in the developing world makes the country currently one of the key actors in global climate governance*" (Vihma, 2011: 70) a role it has specifically courted and sought to defend (e.g. Rajan, 1997 and Rajamani, 2008, both cited in Vihma, 2011: 70).

Outwardly determined and seemingly unchanging in its policy-making on climate change, this policy of no behavioral change was facilitated and underpinned by a resilient, tight-knit, relatively-closed climate change policymaking elite (2011: 81), perceived as such by authors writing many years apart, e.g. M.K. Rajan (1997, cited in Vihma, 2011: 81). Since the policy was settled, large numbers of experts were not required to debate or negotiate it—internally or externally, leading to the Indian negotiating team consisting of just a quarter of the size of Indonesia's at the 2009 United Nations Climate Change Conference 15th Conference of the Parties (COP) 15 and criticism of this fact, and similarly (relatively) small Indian negotiation teams in other global climate governance negotiation forums, a fact criticised in 2013 by N.K. Dubash (Dubash, 2013) amongst others.

6.3 Climate Change Policy: Pre-2014 Attempts at Change

Contemporaneous attempts at challenging the above orthodoxy had met with comparative failure, even when led by a Government Minister. Vhima notes the policy reorientation work of India's Minister of Environment and Forests for the period 2009—2011, Jairam Ramesh, advocated for revised Indian positions on climate change offering "*some degree of credibility internationally*" such that India could convincingly and genuinely demonstrate its desire for a meaningful climate change agreement at COP 15, "*even if this meant compromising on some aspects of the traditional position*", quoting as evidence for this policy activism a leaked letter to the Indian Prime Minister (Vihma, 2011: 76). However, COP 15 was widely seen as a failure, and India's negotiating position cited by many commentators (e.g. Rapp et al., 2010), including citations of "*secret recordings… reveal(ing) how China and India prevented an agreement on tackling climate change at the crucial meeting*" of COP 15.

Writing in 2011 two years after COP 15, former Indian Ambassador to the European Union and former Indian negotiator on climate change issues, Chandrashekhar Dasgupta, charged Ramesh with "*turn(ing) India's climate change policy on its head*" by calling, in 2010, for "*all countries (to) take on binding (climate change) commitments under appropriate legal forms*", including India, a volte face for which, according to Dasgupta (2011), he faced "*a barrage of criticism at home*"; instead, Dasgupta argues (2011) for a return to the former, consistent, policy GoI policy objective, namely that "*India must ensure that the outcome of the negotiations does not unjustly constrain its energy options or facilitate disguised protectionism directed against emerging economies… (lest) its development prospects will be imperilled if it fails to bring its climate change policy back on track*". In 2011 this battle between advocates of Dasgupta's traditional Indian policy perspective, and policy innovators such as Ramesh, remained undecided and the long-term outcome of Indian policy uncertain. Three years later, India held a general election that has provided far greater clarity on the nation's future climate change policy trajectory, albeit contingent with ongoing indeterminacies regarding extent and rate of policy change.

6.4 Climate Change Policy: 2014/5, Two Years of Sustainable Change

However, following the 2014 All-India general election and the election of a majority BJP government, disruptive change came to India. Whilst Ramesh was considered a '*maverick*', e.g. by Scrutton (2011) or worse (e.g. see Dasgupta, 2011), a government Minister whose activities were both enjoyed and constrained by the limited "*level of support from his party and the prime minister's office*" (Vihma, 2011: 75), climate change policymaking change was now to come from the very top and supported by new institutional structures and key policymaking personnel, as encompassed below. In short, it became "sustainable" in the sense of durability as well as environmentally. 2015 saw the adoption of the multilateral "Paris Agreement" on climate change, see below, and it is the year identified as the '*watershed year*' for Indian sustainable energy sector policy both, using the same exact phrase for the same year, by:

- Krisahn Dhawan, CEO of Indian NGO the Shakti Sustainable Energy Foundation (Shakti Sustainable Energy Foundation, 2016), citing both national and international policy developments of the '*new Government*' (2016: 1); and

- Anil Razdan, Mr. Anil Razdan, Former GoI Secretary of Power, who in 2018 cited global agreement on the Paris Agreement, the global Sustainable Development Goals, and the constructive role in the GoI facilitating the negotiation of both of these multilateral agreements (Razdan, 2018).

6.5 Climate Change Policy: The Paris Agreement

Under Prime Minister Modi, India helped to negotiate the United Nations Climate Change Conference 21st COP 21 ('Paris Agreement'), which ratified, and specified India's following Nationally Determined Contribution (NDC) targets for 2030: to lower the emissions intensity of GDP by between 33%–35% below 2005 levels; increase the share of non-fossil based power generation capacity to 40% (equivalent to 26–30% of generation); and to create an additional (cumulative) carbon sink of 2.5–3 gigatonnes of equivalent carbon dioxide through additional forest and tree (United Nations Framework Convention on Climate Change (UNFCC), 2016).

Moreover, and according to the international-in-remit Climate Action Tracker (2017) , India is delivering on its COP 21 commitments: "*India's current climate policies will see it reaching its 2030 non-fossil capacity target, and overachieving its emissions intensity target submitted under the Paris Agreement*" (Climate Action Tracker, 2017).

It would be of significance here to note that the NITI Aayog (see below) authored draft NEP (NITI Aayog, 2017b) and Three-Year Action Agenda, running from 2017/8 to 2019/20 (NITI Aayog, 2017a), has accorded importance to coal. In particular, this meant and means: BJP Leader and Indian Prime Minister Narendra Modi, and the National Institution for Transforming India (NITI, the acronym being a pun on "Planning") Aayog (Commission), which Modi's government established (in 2015) and which he is also Chairman of (Modi abolished in 2014 Independent India's original Planning Commission, established in 1950, three years post-Independence) has approved such this position.

Understanding the dynamics of this shift is important in order to better predict the future of Indian climate change politics. However, it is vital to note that this shift is not as all-consuming and revolutionary as it may first appear. India's accompanying statement (i.e. caveat) to its deposition of COP 21 ratification is as follows:

> The Government of India declares its understanding that, as per its national laws; keeping in view its development agenda, particularly the eradication of poverty and provision of basic needs for all its citizens, coupled with its commitment to following the low carbon path to progress, and on the assumption of unencumbered availability of cleaner sources of energy and technologies and financial resources from around the world; and based on a fair and ambitious assessment of global commitment to combating climate change, it is ratifying the Paris Agreement. (UNFCC, 2018).

The above effectively makes contingent India's climate change policy on, inter alia, poverty reduction, and thus provides a line of continuity back to 1974, at least, when Indian Prime Minister Indira Gandhi made clear to the 1972 Stockholm U.N. Conference on Human Environment that "*on the one hand, the rich look askance at our continuing poverty—on the other, they warn us against our own methods. We do not wish to impoverish the environment any further and yet we cannot for a moment forget the grim poverty of large numbers of people. Are not poverty and need the greatest polluters?*" (Indira Gandhi Memorial Trust, 1992: 15). Indeed, "there is a tradition in Indian foreign environmental policy that frames environmental stewardship and socioeconomic development as contrasting priorities" (Vihma, 2011: 74).

The prognosis herein would be: India both pursuing policies, such as energy transition towards renewables and away from coal, that genuinely do advance global climate change policy goals, whilst also including caveats in Indian COP depositions, such as for COP 21. It is consistent with India seeking *national* benefits from pursuing such policies, e.g. low-cost clean-Indian air power generation, primarily for *national* benefit, and its realism/cynicism that thermal coal-fired power's replacement will indeed be a 'long goodbye' and not anything quicker than that—as per the NITI Aayog documents criticised by the Climate Action Tracker above. Furthermore, since the stated objective is *national* benefits and not *international* collaboration nor good faith *per se: 'progressive realism*', i.e. arguing for a shift in India's growth strategy in favour of more environmental sustainability and internal equity by pursuing 'co-benefits', at home—strategies that are shaped by domestic priorities but also bring climate gains, would be consistent with the application of the concept of '*dual politics*', identified by Vihma as prevalent (Vihma, 2011: 75), whereby Indian politicians aim "*at giving conciliatory (climate change) signals to international audience, and a strident, sometimes populist message for domestic audience(s)*". The what-works pragmatism of '*progressive realism*' also allows for combined and complementary factors to be considered alongside this brief analysis of international climate change diplomacy drivers, in particular: the opportunity of cheap, clean renewable power; and the need to radically improve Indian air quality (a factor alluded to above) and save millions of Indian lives thereby.

Data points in support of this perspective include well-publicised GoI commitments on renewable energy and climate change, for example, and domestically, in late 2014 the new BJP-run GoI established a stretching national target for the country of increasing its solar power installed capacity by a factor of 40 by 2022, from just 2.5 Gigawatts (GW) to 100 GW (Ross, 2016). Even more powerful, the purpose of testing the concept of progressive internationalism as applied to GoI climate change policy and practice, is India's commitment to funding overseas climate change economic development, seeking to collaboratively deliver as part of the International Solar Alliance (ISA) a 1,000 GW target to be met by 2030 (Mohani, 2017) in solar energy of installed capacity across 121 nations, in particular developing nation "solar resource rich countries located between the Tropic of Cancer and the Tropic of Capricorn" (ISA, undated).

6.6 Indian Climate Change Politics: Conclusions

Regardless of the excellent public relations work of Modi's government regarding, *inter alia*, environmental policy (Economist, 2017), the GoI's widely-heralded and internationally-welcomed shift on climate change policy, which is itself hedged by significant small-print caveats, needs to be critically unpacked and examined with regards to its dynamics and the possible, or even likely, unfolding of policy implications into actual change in the make-up of the nation's primary, power sector, energy supply. These insights, recognising positive change on climate change policy and implementation, but critical in its analysis of countervailing factors, is consistent with the conclusion of Progressive Realism as applied to Indian climate change politics.

This represents a change, over a short time period, from the previously identified dominant ethos, namely that of '*Growth-first Stonewallers*', but the evidence is not (yet) there to conclude that the primacy of Progressive Internationalism is imminent in a GoI context. That may come later, perhaps when the accusation of '*dual politics*' has fully lost its validity. These categorisations only matter to the degree that they shed light on India's approach to climate change politics and the reliability and genuineness of any GHG reduction commitments it makes thereby.

The implication of the doctrine of '*Growth-first Stonewallers*' is for India simply not to make any binding commitments or concessions since, as per that doctrine, why should it? The apparent replacement of that ethos by that of progressive realism, as the dominant GoI position on GHG and climate change, implies a nuanced commitment to Indian GHG reduction action. Such nuances are apparent in the contrasting, on the one hand, high public ambition of the GoI on climate change politics, its claim to global political leadership regarding climate change, and the championing of its burgeoning renewable energy sector; and, on the other, the continuing and planned future importance/centrality of its coal sector within Indian downstream energy, the contingent nature of its Paris Agreement commitments on GHG reduction, and the accusation of '*dual politics*', essentially that of telling foreigners what they want to hear whilst carrying on in India's best interests. A complicating factor to this analysis (another nuance) is that a switch to renewable energy from coal may, in fact, be to India's economic advantage; however, the pragmatism of making virtue out of economic necessity is fully consistent with the somewhat cynical DNA of progressive realism, a cynicism that considers international GHG reduction politics and diplomacy not in the highest of regard, and perhaps more akin to a win/lose game.

Even so, and regardless of exact motivation, a progressive realist approach to GHG reduction, such as taken by the current GoI and, to a reducing degree, recent past governments, is consistent with a major push effect on Indian coal with the effect of its increasing crowding out should a serious competitor energy source become available. Should GoI policy pass onto the stage of Progressive Internationalism, this push factor would become yet stronger, and India's energy transition would be (even) more) energised rather than buffeted.

7 Coal Threat: Review of Domestic and International Push Factors

The combination of domestic (see Sect. 4 above) and international (see Sect. 5 above, the discussion focussed in on India and climate change politics) provides a combined force, or overall 'push', against coal's continuing dominance of Indian downstream energy (electricity).

The individual push factors include a Progressive Realist positioning in international climate change diplomacy, the relatively poor quality of Indian mines coal in terms of both ash content (high) and calorific value (low), the ongoing requirement for coal washeries and imports, the experience of (in particular) the Indonesian imported coal price shock, coal mafia and illegality, coal mis-governance (especially as evidenced by Coalgate and SHAKTI), the logistical challenges facing coal's transportation, and the fatal impact of air pollution, in particular as caused by lignite combustion and as felt in India's massive and growing cities.

Overall, these push factors seriously and significantly undermine the primacy of coal in India's downstream energy mix.

7.1 The Emperor's New Clothes?

However, the game isn't up yet for coal in India; it is too early to reliably call the bluff on India's coal emperor and his new clothes. However, the situation is dynamic and fast moving, so watch this space. As recently as 2014, it was observed that "*many policymakers and analysts believe that (coal) must remain the primary source of (Indian) electricity generation for at least the next three to four decades, … (consistent with) ever-expanding coal power generation*" sector in India (Vasudha Foundation, 2014: 4). Whilst this view is ebbing from its near-universality, it is not yet visible as a receding object in India's rear-view mirror.

Perhaps this is because that, even now in April 2018, that the Indian coal "emperor" *does have* new clothes: the GoI's national strategic planning documents, current in March 2018, retain a very significant and important role for coal-fired power, even for many decades into the future. This awkward fact is illustrated and evidence by the figures contained in both GoI's: draft, as of March 2018, National Energy Policy (NEP) (NITI Aayog, 2017b: 34–40); and its promulgated Three-Year Action Agenda, 2017/8 to 2019/20 (NITI Aayog, 2017a: 97–103). Echoing the above debate on king coal's future longevity of rein in India, the Three-Year Action Agenda states that "*the reality of India's energy sector is that around three-quarters of our power comes from coal powered plants and this scenario will not change significantly over the coming decades*" (NITI Aayog, 2017a: 99); the draft NEP likewise states that "*coal based power generation capacity of 125 GW in 2012 is likely to go up to more than 330–441 GW by 2040*" (NITI Aayog, 2017b: 34).

Even so, the draft National Electricity Plan (CEA, 2016) reveals that no additional coal-based capacity, beyond that already under construction, is required during the time period 2017–2022, and that the resulting net increase in installed power capacity "*would fulfill the capacity requirement for the years 2022–2027*" (CEA, 2016: 5.34). This is partly due to increased projected "*capacity addition from gas (of) 4,340 MW, hydro (of) 15,330 MW,* *nuclear is 2800 MW and renewables (of) 1,15,326 MW, as committed capacity during 2017–2022*" (CEA, 2016: xxv).

7.2 Paradigm Shift: From King Coal to Sun King?

Gulagi et al. (2017: 48) argue that "*for India, a 100% RE-based system is achievable and the real policy option*", mainly solar, implying an inferiority of any option falling short of 100% RE supply, on the basis of India achieving the necessary "*storage solutions to balance intermittency… (in particular) batteries, which provide as much as 42% of the total electricity demand*" (Gulagi et al., 2017: 37) in this modelling. This RE energy mix would not just be better for the Indian (and global) environment but would be cheaper too: "*results indicate that a 100% renewable energy based plants and storage technologies installed to achieve a fully RE based power system by 2050 considering the base year's (2015)*" (Gulagi et al., 2017: 37). The above would represent a striking paradigm shift of global significance, both economically and environmentally, in sum and in sun. However, the bar for achieving a paradigm shift from the monarchy of King Coal to the 'Sun King' is surely set far lower than 100%. The Indian reality is likely to be more nuanced, drawn out, and incomplete, than that modeled by Gulagi, Bogdanov and Breyer—which is simply a truism of models in general.

In draft NEP policy terms, India's transition to renewable energy and away from coal is best represented by the '*Greater Sustainability*' key policy objective, and it is driving forward a clean energy transition away from coal in India that is spearheaded by the low-and-lower prices achieved through competitive bidding. Downstream energy market penetration now achieved, its rival the coal sector can and is looking for protection from the other NEP key policy objectives listed, namely '*access at affordable prices*', '*improved energy security*', and '*economic growth*' (NITI Aayog, 2017b). Yet, on many of these points so too can renewable energy: now that renewable energy matches or betters coal on price, so too its broader adoption can match or better coal as a driver of economic growth, affordable access, and national self-sufficiency in reliable (outside of the non-monsoon season) downstream energy supply. In fact, solar and wind have recorded historic low tariffs through competitive bidding in May 2017 at Solar Park Bhadla III: 2.44 Indian Rupees (INR) per unit for solar and INR 2.64 for wind, thereby achieving grid parity (KPMG, 2017: 1). As a result, India's adoption of renewable energy is continuing apace, even "*an irreversible trend*" (KPMG, 2017: 1).

As of November 2017, India had achieved installed solar energy capacity of 14.7 GW and installed 2,247 MW of new capacity in the third quarter of that year alone, such that "*solar continues to be the leading new power generation in India… solar new installed capacity additions accounted for 39 percent of total power capacity additions at the end of the third quarter*" (Mercom India, 2018). Indeed, solar energy's development has been so fast that the commentary on solar energy provided in India's 2006 Integrated Energy Policy (Planning Commission, 2006), can now be read as unduly limited in its aspirations for the sector, or perhaps simply as misplaced and patronising: "*it would not be out of place to mention that solar power could be an important player in India attaining energy independence in the long run. With a concerted push and a 40-fold increase in their contribution to primary energy, renewables may account for only 5 to 6% of India's energy mix by 2031–2032. While this figure appears small, the distributed nature of renewables can provide many socio-economic benefits*" (Shahi, 2007: 169).

However, some of these socio-economic benefits are proving hard for India to accrue, not least with respect to solar energy manufacturing jobs argument: in February 2018 it was reported that 88% of India solar modules and generating equipment is being imported from China, with Indian firms unable to compete against imports that have allegedly benefited from (unknown levels of) Chinese government subsidies (Razdan, 2018). GoI attempts at favoring Indian solar manufacturers through levying a 7.5% import levy from August 2017 were abandoned by May 2018 following a logjam of imports at Indian ports. This is an outcome that both benefits India's power sector through lower costs but also reduces the national benefit, in economic terms, of the energy transition since the manufacturing jobs supported are overwhelmingly Chinese, not India. This contentious outcome mirrors discussions regarding imports of both coal to India and also of imported coal washing technology.

Contentious and/or contested energy sector governance is not limited to any one energy source in India, but regrettably afflicts solar at least partly in the same way as apparent in the thermal energy sector in that country too, and nor is the manufacturing jobs argument notably compelling in respect of Indian content (manufacturing jobs), at least so far as solar energy is concerned. Moreover, coking coal is still required for metallurgical use, given the extremely high temperatures required, in particular in the key, and energy intensive, steel sector of the Indian economy. This is effectively a protected market for (coking) coal that any other form of power production will find it very hard to compete with (Razdan, 2018).

Akin to governance malaise cross-contamination, the risk of underbidding on price by failing to cost in risk that struck India's thermal power sector, in that case by way of Indonesian government policy change, could equally, and through some other causal chain, impact India's renewable energy sector too—possibly with equally damaging results in terms of the credibility of the sector's overall regulation and governance. Indeed, there are initial signs of this already happening, albeit at a far more limited scale than has afflicted coal: an annual 'Economic Survey' official GoI publication (Ministry of Finance, 2018: 72, of Volume 2) reflects that low RE tariffs resulting from auctioning "*though a welcome news, possibly contributed to some demands for renegotiation of the already signed PPAs*" with some discoms hinting "*at the possibility of renegotiating the PPAs signed by them at tariffs higher than those in the recent bids*" at a possible "*risk for investments worth 480 billion INR*".

While the GoI subsequently notified that any such cancellation by either the state or the developer will attract a minimum of 50% penalty of the tariff (Reuters, 2017), an issue linked to the '*spectre*' of downstream energy over-capacity as Indian RE fights for electricity market share against its, coal, incumbent: "*recent cases of reneging of PPAs have further added to the spectre, needing system-wide resolution to the stressed asset problem*" (KPMG, 2017: 1). As a result, one state, "*Andhra Pradesh, which accounts for the highest number of solar projects in the country, is not (now) looking to sign new PPAs in the near term*", due to over-capacity (Reuters, 2017).

Such over-capacity of supply of energy, as a whole, is symptom of the success of renewable energy generation in particular, leading to "*stress in the (energy) sector—thermal to a large extent, and renewable seeing some signs*" (KPMG, 2017: 1), as noted above. As indicated by the KPMG (2017), the resulting pain is being felt unequally between thermal and RE Indian energy producers; that is India's new downstream energy monarch and the old.

Overall, these travails can be seen to have a dampening impact on India's RE sector and energy transition, even as many of the same factors negatively impact its thermal sector too, and to an even greater extent. Whilst a rising tide may float all ships, rising levels of indebtedness may result in them being tied up at harbour, whether they are powered through renewable energy (e.g. wind) or fossil fuels alike. Writing in 2018, the authors of (Frankfurt School—UNEP Collaborating Centre for Climate & Sustainable Energy Finance, 2018: 22), observe Indian renewable energy "*investment oscillating in the $6-14 billion range since 2010—still not reaching the sort of levels that would be required for that country to meet Prime Minister Narendra Modi's ambitious goals for 2022.*" A report of the same year (International Energy Association (IEA), 2018), India's 2017 increase of 6% in renewable energy generation (page 10) is observed to fall only marginally short of its 7% GDP growth rate for that year, but substantially short of the increased level of Indian electricity demand in 2017, reported at "over 12% (or 180 TWh)" (IEA, 2018: 12).

Moreover, whilst Indian targets for greatly increased levels of renewable energy installed capacity may (or many not) be achievable, there is a difference between capacity and utilisation, and that continues to favour coal overwhelmingly: comprising only 58% of installed capacity, as reported in February 2018, coal-fired power accounts for 76% of actual power (electricity) generation (Shahi, 2018). Hence, "*a large selection of informed people have started also cautioning: that we all love renewables, but are we all OK in the targets that we have fixed for ourselves (in India)? …Not from the point of view whether it is achievable, but from the point of view of whether (we) will be able to manage technically, commercially, financially all the things put together*" that are required to make implementing policies born of "*overwhelming support for renewables and overwhelming criticism of coal*", a success in terms of not just installed capacity, but power generation (Shahi, 2018). Shahi, answers his only question by predicting no major shift in the proportional constituents of India's energy mix, in terms of actual power generation rather than installed capacity, over a time period of fifteen to twenty years (Shahi, 2018).

That indeed, would be the prelude to a very 'long goodbye' to Indian coal burning, assuming indeed that an energy transition to renewables happened even thereafter. Whilst it is not necessary to agree with this, very conservative, prognosis, this contrarian view, expressed very recently (to this chapter's publication) in 2018, demands recognition too; if it is to be rejected, then that rejection should be evidence-based and not due to its unwelcome (to many readers) conclusion, i.e. as a matter of wishful thinking.

8 Conclusions

It is in the nature of paradigm shifts that they are hard to predict the outcome of, even in periods when they are occurring (Kuhn, 1996: 83), and it is entirely possible—e.g. as a result of a high impact and highly visible instance of an inconvertibly climate change related extreme weather event occurring in or near India—that the paradigm shift effected could not be from coal to non-coal primary sources of energy generation.

It is possible that India's energy transition, from fossil fuels to cleaner forms of energy such as renewables, is developing at such a pace that coal will be eclipsed as a primary energy source in India far faster than expected, but the prudential principle forbids too hasty a jump to such a conclusion.

What is surely clear even now, however, is that such a paradigm shift is occurring, and that fundamental change is occurring within that sector, change unleashed by a potent mix of different factors and forces; only time will tell how long the resulting goodbye to fossils will be. This, indeed, is the conclusion of Sivaram and Busby (2018), who still predicts a large-scale and significant Indian energy transition towards more (specifically) solar power—it is the timescales of that energy transition that the Review revises to 2022 from the target date of 2020, not whether or not those targets will be met.

Hence, we argue above that the pace of India's energy transition away from, or 'long goodbye' from, coal (in particular) and towards other forms of energy, especially renewables, is a matter of public policy alongside good economics and the (mis)management and governance of the power sector, and of the sourcing of the natural resources necessary to supply that sector—in particular coal.

GoI policy changes outlined above were and are happening in tandem within the context of radically changing energy economics, driven in part by private sector competition and in part by technological change and related cost curves. The economics is in part driven by technological change, and the follow-through impact on Indian climate change policy of the above in sum is openly stated in India, e.g. Anil Razdan, Former Secretary of Power, GoI, whilst reviewing current Indian energy policy and contrasting it to that prior to 2015, stated simply that '*technological development will shift the debate*' once more (Razdan, 2018), the implication being of a clear direction of travel towards cleaner energy that is driven by technological innovation and, thereby transformed economics.

If true, and thus far the evidence supports such optimism, the net result of all of the above changes would be to empower an insurgent competitor to coal in India's energy markets, namely renewable energy, and to undermine coal's ongoing hegemony. The observable fact of an energy transition from coal towards renewables is undeniable, however to what degree this highly dynamic and transition occurs and how fast it does so, remains to be seen. As Jeff Bezos, CEO of Amazon, once advised: "*if you want to build a successful, sustainable business, don't ask yourself what could change in the next ten years that could affect your company. Instead, ask yourself what won't change, and then put all your energy and effort into those things.*" (D'Onfro, 2015). '*What won't change*' is surely the advent of RE and an, ongoing, 'long goodbye' to coal fired power generation, even in India.

References

Adler, B. 2015. *We Could Get a Stronger Climate Deal in Paris if Rich Countries Paid What They Should*. https://grist.org/climate-energy/we-could-get-a-stronger-climate-deal-in-paris-if-rich-countries-paid-what-they-should/.

Bhattacharjee, S. 2017. *India's Coal Story: From Damodar to Zambezi*. London: Sage.

Bose, R. 2014. Supply Constraint: India Inc Has No Option But to Import Coal. *Firstpost*. https://www.firstpost.com/business/indonesia-might-ban-low-quality-coal-export-platts-95708.html.

Buckley, T. and Shah, K. 2017. *India's Electricity Sector Transformation Momentum Is Building; Peak Coal In Sight*. Cleveland: Institute for Energy Economics and Financial Analysis.

Cabinet Committee on Economic Affairs. 2018. *Cabinet Approves Methodology for Auction of Coal Mines/Blocks for Sale of Coal Under the Coal Mines (Special Provisions) Act, 2015 and the Mines and Minerals (Development and Regulation) Act, 1957*.

Caudill, H. 1963. *Night comes to the Cumberlands: A Biography of a Depressed Area*. Atlanta: Little, Brown and Company.

CEA. 2016. *Draft National Electricity Plan, Volume 1, Generation*. [pdf] CEA. http://www.cea.nic.in/reports/committee/nep/nep_dec.pdf.

CEA. 2018a. *All Indian Installed Capacity (in MW) of Power Stations (as on 31.1.2018) (Utilities)*. New Delhi: CEA.

CEA. 2018b. *Monthly Report on Broad Status of Thermal Power Projects in the Country (as on 31.1.2018)*. New Delhi: CEA.

Chatterjee, D. 2017. Gujarat Power Plant Losses: Tata, Adani, Essar stare at Huge Writedowns. *Business Standard*, January 20. http://www.business-standard.com/article/companies/gujarat-power-plant-losses-tata-adani-essar-stare-at-huge-writedowns-117062600737_1.html.

Chikkatur, A. et al. 2007. Tariff-based Incentives for Improving Coal-Power-Plant Efficiencies in India. *Energy* 35: 3744–3758.

Climate Action Tracker. 2017. *India*. http://climateactiontracker.org/countries/india.html.

Comptroller and Auditor General of India. 2012. *Report of the Comptroller and Auditor General of India on the Allocation Coal Blocks and Production Ministry Coal for the Year Ended March 2012*. [pdf] Comptroller and Auditor General of India. https://cag.gov.in/sites/default/files/audit_report_files/Union_Performance_Commercial_Allocation_Coal_Blocks_and_Production_Ministry_Coal_7_2012.pdf.

Cornot-Gandolphe, S. 2016. *Indian Steam Coal Imports: The Great Equation*. [pdf] Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/03/Indian-Steam-Coal-Imports-The-Great-Equation-CL-3.pdf.

Cuddihy, C. 2018. *2017–2018: Coal India Achieves Highest Ever Production and Offtake from Sales Records*. https://www.worldcoal.com/coal/07062018/2017-2018-coal-india-achieves-highest-ever-production-and-offtake-from-sales-records/.

D'Onfro, J. 2015. Jeff Bezos' Brilliant Advice for Anyone Running a Business. *Business Insider*, January 31. https://www.businessinsider.in/Jeff-Bezos-brilliant-advice-for-anyone-running-a-business/articleshow/46082031.cms.

Dasgupta, C. 2011. Sweet Surrender—Jairam Ramesh has Turned India's Climate Change Policy on its Head. *The Telegraph*, January 17. https://www.telegraphindia.com/1110117/jsp/opinion/story_13451487.jsp.

Dockery, D. and Evans, J. 2017. Tallying the Bills of Mortality from Air Pollution. *The Lancet* 389:(10082): 1862–1864.

Dogra, S. 2016. India's Coal Imports to Reach 160 Million mt in Fiscal 2016–17. *Platts S&P Global blog* [blog], November 18. https://www.platts.com/latest-news/coal/newdelhi/indias-coal-imports-to-reach-160-million-mt-in-27712301.

Dubash, N. 2009. *Towards a Progressive Indian and Global Climate Politics*, Working Paper 1/2009. [pdf] Centre for Policy Research Climate Initiative. http://www.cprindia.org/system/tdf/working_papers/1253785461-CPR%20WP%202009-1_Dubash.pdf?file=1&type=node&id=3565&force=1.

Dubash, N.K. 2013. Of Maps and Compasses: India in Multilateral Climate Negotiations. In: Sidhu, W. P. S., Mehta, P. B. and Jones, B. (Eds.) *Shaping the Emerging World: India and the Multilateral Order*. Washington, DC: Brookings Institution Press.

Economist. 2017. Narendra Modi is a Fine Administrator, But Not Much of a Reformer. *The Economist*, June 24. https://www.economist.com/news/briefing/21723815-tax-reform-does-not-go-far-enough-land-and-labour-reforms-have-barely-been-tried-narendra-modi.

Financial Express. 2017. Electricity Consumption in India: Power Demand to Rise 7% CAGR in 5 Year (sic). *Financial Express*, June 14. http://www.financialexpress.com/economy/electricity-consumption-in-india-power-demand-to-rise-7-cagr-in-5-year/716957/.

Frankfurt School—UNEP Collaborating Centre for Climate & Sustainable Energy Finance, 2018. *Global Trends in Renewable Energy Investment 2018*. [pdf] Frankfurt School—UNEP Collaborating Centre for Climate & Sustainable Energy Finance. http://fs-unep-centre.org/sites/default/files/publications/gtr2018v2.pdf.

Ghoshal, D. 2013. Regulation Flares Indonesian Coal Prices. *Business Standard*, January 20. http://www.business-standard.com/article/economy-policy/regulation-flares-indonesian-coal-prices-111071900009_1.html.

Goyal, P. 2017. India's Coal Import Drops 25% in Dec 2016 (YoY); Aims to Eliminate Coal Dependency in the Next Few Years. *Twitter*, January 18. https://twitter.com/PiyushGoyal/status/821621903727149059/photo/1.

Greenpeace. 2013. *Coal India Running on Empty*. [pdf] Greenpeace. http://www.greenpeace.org/india/Global/india/report/2013/Coal-India-Running-on-Empty.pdf.

Gulagi, A., Bogdanov, D. and Breyer, C. 2017. The Demand for Storage Technologies in Energy Transition Pathways. Towards 100% Renewable Energy For India. In: EUROSOLAR e.V., *11th International Renewable Energy Storage Conference, IRES 2017, 14–16 March 2017, Düsseldorf, Germany*. Bonn: EUROSOLAR e.V.

Hiro, D. 2016. *Quarter Century of Market Reform Leaves India Richer With Wider Inequality*. https://thewire.in/economy/a-quarter-century-of-market-reform-leaves-india-richer-with-wider-inequality.

IEA. 2017a. *World Energy Outlook 2017*. Paris: IEA.

IEA. 2017b. *Key World Energy Statistics*. Paris: IEA.

IEA. 2018. *Global Energy & CO_2 Status Report 2017*. [pdf] IEA. https://www.iea.org/publications/freepublications/publication/GECO2017.pdf.

IIFL. 2018. *Why Availability of Coal at Plants Has Been Hit*. https://www.financialexpress.com/industry/why-availability-of-coal-at-plants-has-been-hit-iifl-explains/1134207/.

Indian Express. 2017. What is Coal Scam? *Indian Express*. http://indianexpress.com/article/what-is/manmohan-singh-cbi-coalgate-coal-block-allocation-cag-report-what-is-coal-scam-4668265/.

Indian Supreme Court. Writ Petition No. 120 of 2012, 2012.

Indira Gandhi Memorial Trust. 1992. *Safeguarding Environment*. New Delhi: New Age International.

Invest India. 2018. *Ports and Shipping*, June 24. https://www.investindia.gov.in/sector/ports-and-shipping.

ISA. Undated. *About ISA*. http://isolaralliance.org/AboutISA.aspx.

Kamboj, P. and Tongia, R. 2018. *Indian Railways and Coal: An unsustainable interdependency*. New Delhi: Brookings Institution India Center.

KPMG. 2017. *Transition of the Energy Sector in India*. [pdf] KPMG. https://assets.kpmg.com/content/dam/kpmg/in/pdf/2017/11/Transition-of-the-energy-sector-in-India.pdf.

Kuhn, S. 1996. *The Structure of Scientific Resolutions*. 3rd ed. Chicago and London: The University of Chicago Press.

Lahiri-Dutt, K. 2007. Illegal Coal Mining in Eastern India: Rethinking Legitimacy and Limits of Justice. *Economic and Political Weekly* 42(49): 57–66.

Mahr, K. 2013. As Deadly Floods Hit India, Kerry Calls on New Delhi to Address Climate Change. *Time*, June 24. http://world.time.com/2013/06/24/as-deadly-floods-hit-india-kerry-calls-on-new-delhi-to-address-climate-change.

Manohar Lal Sharma v The Principal Secretary & Ors. 2012. Writ Petition (CRL.) No. 120, Indian Supreme Court.

Maslow, A. 1943. A Theory of Human Motivation. *Psychological Review* 50: 370–396.

Mathur, R., Chand, S. and Tetsuo, T. 2003. Optimal Use of Coal for Power Generation in India. *Energy Policy* 31(4): 319–331.

MEMR. 2010. *Regulation Number 17 Year 2010 regarding Procedure for the Stipulation of Benchmark Pricing for Mineral and Coal*. Jakarta: State Gazette of the Republic of Indonesia.

Mercom India. 2018. *Q3 2017 India Solar Quarterly Market Update—2.2 GW Installed in Q3 2017*. https://mercomindia.com/product/q3-2017-india-solar-quarterly-market-update/.

Ministry of Coal. 1993. *Eligibility to Coal Mining*. [pdf] Ministry of Coal. https://coal.nic.in/sites/upload_files/coal/files/curentnotices/Eligibiltytocoalmining_0.pdf.

Ministry of Coal. 2007. *Office Memorandum, Subject: New Coal Distribution Policy*. https://www.coal.nic.in/sites/upload_files/coal/files/curentnotices/28-06-2018-b.pdf.

Ministry of Coal. 2014. *Coal Reserves, 2014*. https://coal.nic.in/content/coal-reserves.

Ministry of Finance. 2018. *Economic Survey 2017–18 (Volume 1 and Volume II)*. Oxford: Oxford University Press.

Ministry of Law and Justice. 2015a. *Mines and Minerals (Regulation and Development) Amendment Act*. [pdf] Ministry of Law and Justice, 2015. http://www.eisourcebook.org/cms/February%202016/India%20MINES%20AND%20MINERALS%20(DEVELOPMENT%20AND%20REGULATION)%20Act%202015.pdf.

Ministry of Law and Justice. 2015b. *Coal Mines (Special Provisions) Act, 2015*. [pdf] Ministry of Law and Justice, 2015. http://www.coalcontroller.gov.in/writereaddata/files/ActsRule/CoalMineSplProviAct2015.pdf.

Ministry of Mines. 1957. *India Mines and Minerals (Regulation and Development) Act, 1957*. [pdf] Ministry of Mines. http://www.eisourcebook.org/cms/January%202016/India%20Mines%20and%20Minerals%20(Regulation%20and%20Development)%20Act,%201957.pdf.

Ministry of Statistics and Programme Implementation. 2017. *Energy Statistics, 2017*. New Delhi: Central Statistics Office, Ministry Of Statistics and Programme Implementation.

MoEF. 1988. *National Forest Policy, 1988*. New Delhi: MoEF.

Mohan, A. 2017. *From Rio to Paris: India in Global Climate*. [pdf] Observer Research Foundation. https://www.orfonline.org/wp-content/uploads/2017/12/ORF_Occasional_Paper_130_Climate_Mohan.pdf.

Mohani, V. 2017. India-Led Solar Alliance to Add 1,000GW of Energy by 2030. *The Times of India*, November 16. https://timesofindia.indiatimes.com/home/environment/the-good-earth/india-led-solar-alliance-to-add-1000gw-of-energy-by-2030/articleshow/61665841.cms.

Mukherjee, S. and Choudhuri, S. 2013. Unorganized Laborers in Dhanabad-Jharia Coal Mines. *IOSR Journal of Economics and Finance (IOSR-JEF)* 1(3), September–October 2013: 35–39.

NITI Aayog. 2017a. *India Three Year Action Agenda*. New Delhi: NITI Aayog.

NITI Aayog. 2017b. *Draft National Energy Policy*. [pdf] NITI Aayog. http://niti.gov.in/writereaddata/files/new_initiatives/NEP-ID_27.06.2017.pdf.

OECD/IEA. 2018. *Global Energy & CO2 Status Report 2017*. Paris: OECD.

Parakh, P.C. 2014. *Crusader or Conspirator: Colagate and Other Truths*, Delhi: Manas Publications.

PIB. 2018. *Coal Reserves*. http://pib.nic.in/newsite/PrintRelease.aspx?relid=177058.

Planning Commission. 2006. *Integrated Energy Policy*. [pdf] http://planningcommission.gov.in/reports/genrep/rep_intengy.pdf.

Rachman, G. 2018. Narendra Modi Aims to Double Size of Indian Economy by 2025. *Financial Times*, January. https://www.ft.com/content/156e5e7e-0047-11e8-9650-9c0ad2d7c5b5.

Rapp, T., Schwägerl, C. and Traufetter, G. 2010. The Copenhagen Protocol, How China and India Sabotaged the UN Climate Summit. *Spiegel*, May 5. http://www.spiegel.de/international/world/the-copenhagen-protocol-how-china-and-india-sabotaged-the-un-climate-summit-a-692861.html.

Razdan, A. 2018. *Mr Anil Razdan, Chairman, World PetroCoal Congress, Chairman, Energy And Environment Foundation* [video online]. https://www.youtube.com/watch?v=g9js9RhSeHM&feature=youtu.be.

Reuters. 2017. The Copenhagen Protocol, India Bars States from Independently Exiting, Modifying Solar Projects. *Reuters*. https://af.reuters.com/article/energyOilNews/idAFL4N1LE3A3.

Rio Tinto. 2014. *Chartbook*. [pdf] http://www.riotinto.com/documents/investors_databook/chartbook.pdf.

Ross, K. 2016. India Charts a Roadmap to Achieve Ambitious Solar Targets. *World Resources Institute Blog* [Blog], May 31. http://www.huffingtonpost.co.uk/daniel-wylie/daniel-wylie-scottish-independence_b_5984340.html.

Sanhati. 2011. *Overview of Coal Mining in India: Investigative Report from Dhanbad Coal Fields*. http://sanhati.com/excerpted/3798/.

Scrutton, A. 2011. Maverick Ramesh Makes Waves. *Reuters*. https://www.reuters.com/article/idINIndia-54539520110131.

Shahi, R. 2007. *Towards Powering India: Policy Initiatives and Implementation Strategy*. New Delhi: Excel Books.

Shahi, R. 2018. *Mr. R. V. Shahi, Chairman, Energy Infratech Private Limited & Former Secretary Power, Government of India deliver a Keynote Address during 8th World PetroCoal Congress held on February 15–17, 2018 at New Delhi, India* [video online]. https://www.youtube.com/watch?v=rJxopsXwxHk&feature=youtu.be.

Shakti Sustainable Energy Foundation. 2016. *Cleaner Energy. More Power to India*. [pdf] Shakti Sustainable Energy Foundation. http://shaktifoundation.in/wp-content/uploads/2016/03/Newsbook-2015.pdf.

Sivaram, V. and Busby, J. 2018. Still Shinning? Our Third Annual Review on Solar Scale-up in India. *Council on Foreign Relations Blog* [Blog], February 20. https://www.cfr.org/blog/still-shining-our-third-annual-review-solar-scale-india.

Srivastava, S. 2018. *Co-Chairman Steering Committee, World PetroCoal Congress, Former Secretary Coal* [video online]. https://www.youtube.com/watch?v=02RuiYSZtwc&feature=youtu.be.

Tongia, R. 2003. *The Political Economy of Indian Power Sector Reforms*. [pdf] Stanford University. https://pdfs.semanticscholar.org/9639/07d0425aa8a5d222707cd1feaacc74b75597.pdf.

UNDP. 1997. *Governance for Sustainable Human Development*. New York: UNDP.

UNFCC. 2016. *India's Intended Nationally Determined Contribution: Working Towards Climate Justice*. [pdf] UNFCC. http://www4.unfccc.int/ndcregistry/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf.

UNFCC. 2018. *Paris Agreement—Status of Ratification*. [pdf] UNFCC. http://unfccc.int/paris_agreement/items/9444.php.

Vasudha Foundation. 2014. Electricity for All in India, Why Coal is Not Always King. [pdf] *Vasudha Foundation*. http://www.vasudha-foundation.org/wp-content/uploads/Electricity-for-all-in-India-Why-Coal-is-not-always-king1.pdf.

Venugopal, R., Patel, J.P. and Bhar, C. 2016. Coal Washing Scenario in India and Future Prospects. *International Journal of Coal Science and Technology* 3(2): 191–197.

Vihma, A. 2011. India and the Global Climate Governance—Between Principles and Pragmatism. *Journal of Environment & Development* 20(1): 69–94.

World Bank. 1992. *Governance and Development*. [pdf] World Bank Group. http://documents.worldbank.org/curated/en/604951468739447676/pdf/multi-page.pdf.

10

Transitioning to a Low Carbon Economy: Is Africa Ready to Bid Farewell to Fossil Fuels?

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1 Introduction

The need for a global transition to a low carbon economy has gained a lot of attention in recent years following the adoption of the Paris Agreement in 2015 whose main aim is to reduce greenhouse gas (GHG) emissions, thus necessitating a shift from fossil fuels to renewable energy sources. Although many developed countries especially in Europe are able to more easily shift to renewables, the question that arises is, are developing countries such as those in Africa ready for this shift? The strong correlation between economic development and energy consumption also raises the question as to how African countries can address energy poverty and access challenges while at the same time protecting the environment? Given the energy challenges and low rates of economic development in most Sub-Saharan African (SSA) countries, this chapter poses the following question: are these countries ready to say goodbye to fossil fuels? Meeting developmental goals in these countries and addressing energy challenges will indeed require massive investments in the energy sector, especially if the focus is on clean energy sources such as renewables.

Generally, SSA have vast energy resources, including both conventional and unconventional resources, most of which are untapped. The region, for instance has a natural gas potential of approximately 503.3 Trillion Cubic Feet (Tcf) (BP, 2017). However, low electrification rates coupled with heavy reliance on inefficient energy sources such as traditional biomass are rampant.

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Fluctuating fossil fuel prices coupled with their negative impact on the environment, has led to massive investments and an increase in the development of alternative clean energy sources (Nalule, 2018). Renewable Energy Sources (RES) are now widely recognised as not only being pivotal to solving SSAs energy access challenges, but also those concerning climate change (Avila et al., 2017). Taking into consideration that SSA has massive energy resources such as coal and other fossil fuels, and given the region's energy access challenges, the fundamental question that arises in this chapter is whether these resources could be utilised in a sustainable manner to address the challenge of energy access? Is a transition to low carbon economy in SSA a myth and if so, what practical steps need to be considered?

In addressing the questions raised above, a four-step framework is employed. Section 2 of this chapter discusses the definition and evolution of energy transition and addresses the developments in Africa with respect to a transition to a low carbon economy; Sect. 3 discusses African efforts in decarbonisation, including the deployment of renewables, energy efficiency and electric vehicles (EVs); Sect. 4 examines climate change in the context of Africa and Sect. 5 sets out the concluding remarks. Although this chapter looks at Africa in general, emphasis is placed on SSA.

2 Energy Transition: African Perspective

2.1 Understanding Energy Transition

The main global topic in the energy sector right now is 'a transition to a low carbon economy'. However, this has proved difficult not only in Africa but also Europe and other parts of the globe although the European Union is rightly recognised as leading efforts to address climate change through the development of low carbon legal and policy frameworks (Wood, 2018); however, as discussed below, European countries do not always act so 'green' in Africa and abroad. Before we even dwell on the meaning of energy transition, we cannot ignore the recent protests in France by the 'gilets jaunes', who have complained about the sharp increase in diesel taxes—taxes motivated by environmental and climate concerns. France has been a great supporter of the climate change conference having even hosted the 2015 Conference on Climate Change in Paris. However, the protests that started in November 2018 are a reflection of how hard it is to smoothly transition to a low carbon economy.

Energy is central to the economic development of a country, it is used in everyday life for lighting, heating, cooking and transport, to mention but a few (Nalule, 2018). A transition in the energy sector therefore is capable of having a significant impact on the ways of life of different people both socially and economically. This has proved true in France and, in this regard, while suspending the fuel tax increase, the French Prime Minister Édouard Philippe, in a statement noted that he understood the protestors' anger, "…*it is the anger of the French who work and work hard, but still have difficulty making ends meet, who find their backs against the wall. They have a sense of profound injustice at not being able to live a dignified life when they are working*" (Willsher, 2018). This statement clarifies the realities of not only poorer people in Europe but also those in African countries, and this in turn makes it clear that countries cannot simply say goodbye to fossil fuels without finding cheaper alternatives. It is one thing to have ambitious policies on paper and it is another thing to put these in practice and make them acceptable to struggling populations.

2.2 Definition of Energy Transition

Understanding energy transition necessitates understanding the term transition. In simple terms, transition means the process or a period of changing from one state or condition to another (Oxford Dictionary, 2019). With respect to energy transition, there is no agreed definition. Some scholars have defined it as the change in the composition (structure) of primary energy supply, the gradual shift from a specific pattern of energy provision to a new state of an energy system (Smil, 2010). Basically, energy transition involves the long-term structural change to energy systems. We note here the influence of international institutions in the formulation of the energy transition definition and focus. This influence is mainly driven by these institutions' long-term strategy and objectives. Taking the example of the International Renewable Energy Agency (IRENA), it focuses its definition on a transition to renewables. In this regard, IRENA defines energy transition as a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. According to IRENA, the focus of this transition is to tackle climate change by reducing energy-related CO_2 emissions and thereby increasing renewable energy and energy efficiency measures while at the same time reducing the consumption of fossil fuels (IRENA, 2018). In brief, this definition suggests a transition to a low carbon economy, a topic which has attracted massive literature (Niamir et al., 2018).

The above definition notwithstanding, discussions about energy transition should take into consideration the availability of energy resources, the affordability of these resources, the reliability, efficiency, sustainability and the costs of obtaining energy carriers. But we note that all the above elements cannot be fulfilled at once. There are instances where the resources are available and affordable, but not sustainable or in the case of fossil fuels not environmentally friendly. This therefore highlights the progressive character of energy transition, implying that it has to happen gradually and in different stages. Europe is a good example of the progressive character of energy transition, for instance, initially, in the nineteenth century, the focus for European countries was to shift from wood and water power to coal; in the twentieth century the focus was to shift from coal to oil; in the twenty first century the focus is to shift from fossil fuels to renewable energy. As will be discussed in the next section, the situation for countries in SSA is different, as most of these countries' focus is to shift from wood to electricity grids (even if these are powered by high-carbon intensity energy resources such as coal). Geography is key in understanding energy transition, for instance, in the post-Communist states of Eastern and Central Europe (ECE) energy developments have focused on the geographical position of these countries between exporting states of the former Soviet Union, on the one hand, and the energy-importing states of Western and Southern Europe, on the other; thus, energy transition has in the past focused on introducing competition in the energy sector through liberalization (Bouzarovski, 2009). It is also noted that post-socialist reforms of energy industries in this region provide unique insights into the complex relations of power, economic transformation and spatial inequality that govern energy production and consumption (Bouzarovski, 2009).

Taking stock of the above, we note that in developed countries such as those in Europe, one of the recognised and celebrated transitions was a historic shift from biomass to fossil fuels. But before we accept a particular global definition of energy transition (current focus being a shift from fossil fuels to renewables), we need to recognise that developing and developed countries face different energy challenges, and as such the definition should apply differently in these countries. Of course, there is literature that analyses the historical shift and evolution of energy usage. In the distant past, we notice that traditional families in Europe relied on the burning of biomass to meet their energy needs. The nineteenth century was characterised by industrialisation necessitating the transition from wood and water power to coal in the nineteenth century, or from coal to oil in the twentieth (Bouzarovski, 2009). Historically, developed countries such as the UK were heavily reliant on coal to the extent that when faced with a 'coal panic' in the late nineteenth century, extreme solutions were suggested including: the urging of military strategists to seize control of coal reserves in foreign lands; and the urging of companies to drive their workers harder to increase the domestic production of coal (Podobnik, 2006). These suggested solutions were however rejected not only by unions inside Britain but also other colonial powers (Podobnik, 2006). Technological innovation and the development of new fuels has in recent years led the UK to focus on a transition from fossil fuels to low carbon energy resources.[1] These developments in the energy sector therefore reveal the progressive nature of energy transition and as such developing countries and developed countries are at different stages of this transition.

2.3 Energy Transition from an African Perspective

As discussed in the previous section, developing and developed countries face different energy challenges. For instance, whereas in developed countries the use of biomass such as charcoal and firewood is predominantly historical and a topic of the nineteenth century, developing countries such as those in SSA, in contrast, on the other hand are still struggling with a reliance on traditional energy (Nalule, 2018). Understanding the difference between modern energy and traditional energy is also key in understanding energy transition from an African perspective. Modern energy can be distinguished from traditional energy by looking at the quality of energy used, for instance with regard to traditional energy candles, kerosene, and lamps are used for lighting; and firewood for cooking (Nalule, 2018). On the other hand, with regard to modern energy, electricity, natural gas, and liquefied natural gas (LNG) are used for lighting and cooking, respectively (Nalule, 2018). The focus for SSA countries is access to electricity. We note that electricity in its natural form tends to appear as lighting and static, the technological advancement have enabled primary sources of energy such as coal, nuclear power, running water and of late renewable energy sources to provide this electricity. In this respect, for a country with more than 80% of the population lacking electricity, the focus will not entirely be on the kind of primary energy used to provide this electricity, but rather on ensuring that people shift from wood and biomass usage.

[1] Low carbon energy sources are typically defined as including renewable energy sources and nuclear power; carbon capture and storage technologies are also typically included in this category. Others also argue that natural gas should be viewed as a 'transition' fuel in switching from other fossil fuels like coal as gas is estimated to produce approximately 50% of the GHG emissions of coal (for a more detailed discussion of renewable and low carbon energy technologies and fuel sources and concerns over definitions, see Wood (2018)).

Energy transition is therefore influenced by various factors including: geography; social and economic situation; political climate; availability of energy resources; the country's energy strategy (in the UK for instance the national strategy focuses on a transition to a low carbon economy). Literature has flourished with respect to the latter and as such many energy scholars have focused on a transition to a low carbon economy (Bulkeley et al., 2010; Silver and Marvin, 2018). Discussions on the influence of geography to a low carbon economy are also worth highlighting given the fact that geographical and economic situations have a significant influence on energy transition. These discussions by scholars have also enabled the introduction of various concepts that are believed to have an influence on energy transition including: location, landscape, territoriality, spatial differentiation, scaling, and spatial embeddedness. Bridge et al. (2013) note that more attention to the spaces and places that transition to a low-carbon economy will produce can help better understand what living in a low-carbon economy will be like (Bridge et al., 2013).

Additionally, recognising the differences in societies, literature has flourished discussing terms such as energy justice, climate justice and just transition. Climate justice takes into account the need to share the benefits and burdens of climate change from a human rights perspective; energy justice refers to the application of human rights across the energy life-cycle (Jenkins et al., 2016; Sovacool and Dworkin, 2015); and environmental justice aims to treat all citizens equally and to involve them in the development, implementation and enforcement of environmental laws, regulations and policies (Heffron and McCauley, 2018). A concept that is of relevance to this chapter is that of a just transition which aims to capture the just process when societies move towards an economy free of CO_2 emission (see Chaps. 19, 20 and 21 for further discussion of energy justice and just transitions). It has been noted that justice is an important element to the transition, because often the rhetoric of governments, companies, institutions and researchers simply discuss 'a transition to low carbon economy' with no concomitant mention of 'just' (Heffron and McCauley, 2018). Scholars have also expressed the need to have a united justice, i.e. a concept that aims to unify all the other concepts of justice including climate, energy and environment (Heffron and McCauley, 2018).

Drawing from the discussion above, it is worth exploring what a just transition means to developing countries such as those in SSA. The Oxford Dictionary defines 'just' to mean behaving according to what is morally right and fair (Oxford Dictionary, 2019.). At this juncture, it is worthwhile to explore the energy access challenges in developing countries. Globally, it is estimated that approximately 1.2 billion people have no access to modern energy such as electricity and nearly 3 billion people rely on traditional biomass (such as wood and charcoal) for cooking and heating. (United Nations Foundation, 2019). This number is high in SSA with over 290 million people having no access to modern energy such as electricity (International Energy Agency (IEA), 2014: 13). This is despite the region's richness in energy resources with an estimated 65 billion barrels of proven oil reserves, equivalent to around 5% of the world total (IEA, 2014: 14). According to the African Development Bank (AfDB). Africa's power connectivity stands at 39 MW per million inhabitants, the lowest for any developing region. Besides having the lowest level of connectivity in the region, recurrent outages and load shedding are also a major challenge (African Development Bank Group (AfDB, 2019). The AFDB also estimates that more than 30 African countries experience recurrent outages, with opportunity costs amounting to as much as 2% of the total annual value of the economy (AfDB, 2019). Taking stock of the discussion above, a question arises: is it morally right and fair to have over 200 million people lacking access to electricity? The answer to this question is definitely in the negative.

In this respect, it is essential to seriously take into consideration the influence of geography and economic situation of countries before making a transition to a low carbon economy a global goal. The ability of a society to shift from one form of energy to another is basically influenced by that society's economic prosperity, geographical structure and international relations (Bridge et al., 2013). In an African perspective, with regard to energy transition, we have to note that a majority of the people especially in rural areas live below the poverty line and heavily rely on firewood and charcoal to meet their energy needs (Nalule, 2018). As such these people cannot easily shift from traditional biomass to electricity (renewable based) or LNG unless if these sources of energy are made more affordable for them. Of course, the situation is different for urban Africa, where people basically rely on modern energy including electricity and LNG: additionally, energy is essential for the booming urbanisation taking place in different African countries (Silver and Marvin, 2018). In this respect, the energy access challenges in various developing countries have to be put into consideration before we can globally agree to say goodbye to fossil fuels and other traditional energy sources. This said, a just transition in SSA should focus on utilising all energy sources to not only address energy access challenges but also to ensure the economic development of these countries. Of course, environmental protection should be at the centre of this transition, and in this regard clean technology should be employed to utilise fossil fuels. Also, it is important to note that energy transition is a progressive process and it differs depending on the country and region concerned. It is true there are some countries in SSA that can perhaps more easily transition to a low carbon economy; also, people in urban areas can transition to a low carbon economy more easily than those in rural areas. All these need to be considered when discussing a transition to a low carbon economy in Africa.

3 African Efforts in Decarbonisation

Decarbonisation in simple terms refers to the reduction or removal of carbon dioxide from energy sources. This has been a major goal for many countries aiming to decarbonise the power sector by among others increasing the share of low carbon energy such as renewables; additionally, the reduction of GHG emissions from fossil fuel use via carbon capture and storage technologies and switching from coal to gas has also been identified as forms of decarbonisation, although not without controversy. Although there are various issues to be addressed with regard to decarbonisation. In this section, the focus is on the renewable energy sources in the African energy sector. Before discussing renewables, a brief overview of reliance on fossil fuels will be discussed together with climate change challenges.

3.1 Fossil Fuels Deployment in SSA

As mentioned in the previous section, there are various energy challenges in SSA including lack of access to electricity and heavy reliance on biomass fuel. In the Southern African countries, it has been observed that besides the Democratic Republic of Congo (DRC) and Mozambique, most countries in the Southern African Development Community (SADC) region have a supply deficit. According to the SADC Energy Monitor, as of November 2015, the Southern Africa Power Pool (SAPP) installed generation capacity stood at 61,859 MW, although available generation was only 46,910 MW (SADC, 2016: 33).

SAPP heavily relies on coal for electricity generation and this accounts for over 62% of the total generation capacity, followed by renewables including hydro at 21%, wind at 43%, solar PV at 2.9%, and distillate at 4.4%. Although traditional biomass in the form of firewood is relied on by most people in rural areas, we note that in terms of electricity generation, this has minimal capacity and as such biomass generally stands at 0.07% of the SAPP installed generation capacity (SADC, 2016: 33).

3.1.1 Coal

Coal is a major source of energy not only in Africa but also other regions including Asia, Europe, and America. It provides approximately 41% of the world's electricity needs, and global coal supply is predicted to increase at an average rate of 0.6% through 2020 (IEA, 2019). However, there are concerns that developed and developing countries should reduce their coal dependence for energy production and instead look to other cleaner technologies such as renewables (Nalule, 2018).

Before we explore coal dependence in SSA countries, it is worth noting that reliance on fossil fuels is not only a problem in SSA but also other parts of the globe including the EU in countries such as Poland (Leal-Arcas et al., 2019). Despite hosting the 2018 COP24 which aims at reducing GHG emissions by reducing dependence on fossil fuels, Poland is heavily reliant on coal (Euractiv, 2018). The country is indeed endowed with massive coal resources. According to the World Energy Council, global proven hard coal resources are estimated at 665 billion tonnes and Poland accounts for 8.3% of these (676 billion tonnes). As of 2016, total proven hard coal resources in Poland amounted to 58,579 million tonnes and economic reserves were 2,982.72. In 2017, out of the 81 million tonnes of hard coal produced in Europe, 65.5 million tonnes were produced from Poland. With respect to energy mix, in 2015, Poland's total primary energy supply was dominated by coal (50.8%), oil (24.5%), gas (14.6%), wind (1.0%) and hydro (0.2%). The coal resources in Poland are worth exploring given the country's history of opposing EU carbon reduction goals. For instance, in June 2011, Poland was the only EU member state to oppose a more ambitious 25% 2020 emissions reduction target. The country also opposed the EU energy talks when it refused to back a plan that would reduce the surplus of Kyoto carbon permits.

The above situation therefore highlights the fact that transitioning to low carbon economy is not only hard to achieve in SSA but also other parts of the globe. Back to SSA, taking the example of Southern Africa, coal is the most dominant source of electricity in the SADC region, contributing to over 60%, followed by hydro, which contributes 21% of electricity generation capacity. This heavy reliance on coal in SAPP can be attributed to the fact that South Africa dominates the power generation as it accounts for 76% of the overall generation capacity. Moreover, as of March 2015, at least 86% of South Africa's total generation capacity of 44,170 MW came from coal fired plants, while 82% of Botswana's electricity was produced from coal, and 63% for

Zimbabwe. High reliance on coal for electricity in South Africa is the main reason for the high GHG emissions.

It has been argued that hydroelectricity could play a big role in reducing South Africa's GHG emissions, especially given the large hydro schemes in the Congo and Mozambique, which could provide an alternative electricity source for South Africa (Mukheibir, 2017). Besides the option of hydroelectricity to replace coal, other lower GHG emission electricity generation options such as imported natural gas feeding into combined-cycle gas turbines (CCGTs) and the pebble bed modular reactor have also been suggested for South Africa especially due to their low GHG emissions (Mukheibir, 2017). Although coal is a main source for South Africa, Botswana, and Zimbabwe, other SADC countries such as DRC, Lesotho, Malawi, and Zambia solely rely on hydropower as a source of electricity generation. Recent criticism over the use of coal has encouraged investments in other energy sources including oil, gas, and renewables, in the generation of electricity. There are also plans for more modern technologies such as supercritical, fluidised bed combustion, and integrated gasification combined-cycle plants, although these still incentivise the use of fossil fuels and have associated problems for addressing climate change.

3.1.2 Oil

Africa is home to massive oil resources. Generally, oil is considered the most important source of energy as it is used in automobiles, planes, trains, and ships among many other uses. In terms of access to energy, electricity is also generated from distillate power plants which basically generate electricity using diesel fuel in countries such as Mozambique, Namibia, and Tanzania and it accounts for close to 5% of the total electricity generation. In this regard, oil resources can contribute in addressing the challenge of energy poverty in Africa (Nalule, 2018).

3.1.3 Fossil Fuels and Low Carbon Transitions in Africa

Indeed, over 80% of Africa's electricity is generated from fossil fuels (Mekonnen et al., 2018).

Additionally, global demand for fossil fuels is expected to grow by around a third by 2040 (BP, 2018). This increase is mainly driven by increasing prosperity in fast-growing emerging economies such as China and India.

Additionally, the increase is also supported by population growth, estimated to increase by around 1.7 billion to reach nearly 9.2 billion people in 2040 (BP, 2018). Moreover, the global boom in urbanisation is projected to increase, as almost 2 billion more people are likely to live in urban centres by 2040 and Africa is projected to contribute one-third of this increasing urbanisation: Productivity levels are also expected to increase, and it is estimated that 2.5 billion people will be lifted from low incomes (BP, 2018). All these global developments imply that Africa will require massive energy resources, especially fossil fuels, to not only cope with the population growth but also with booming urbanisation. Moreover, industrialisation is escalating in most African countries necessitating further demand, again most likely from fossil fuels. Currently, the industrial sector (including the non-combusted use of fuels) consumes around half of all global energy and feedstock fuels, residential and commercial buildings account for 29%, transport 20%, and other sectors account for the remainder (BP, 2018). In the BP Evolving Transition scenario, the industrial sector is expected to account for around half of the increase in energy consumption (BP, 2018).

The simple truth, then, is that Africa will require more energy to meet the anticipated growth in urbanisation, population growth and industrialisation. It is naive to think somehow that the continent will by-pass using fossil fuels in this context, particularly with respect to domestic sources of oil, gas and coal. This does not, however, mean that 'The Long Goodbye' to fossil fuel use in Africa will necessarily be that long. Despite the potential of fossil fuels to tackle the challenge of energy access in SSA and to ensure economic development, there are various limitations to the development of this sector including lack of exploration to increase the size of proven reserves; lack of human skills and resources; and lack of essential infrastructure such as pipelines, storage, and refining facilities (Nalule, 2018). With respect to energy infrastructure, it is notable that there are limited petroleum refineries on the African continent leading to Africans being unable to fully benefit from their massive oil resources. The continent, despite its massive oil and gas resources, remains a net importer of petroleum products, thus necessitating the need to invest in more oil refineries. For instance, the African continent has around 46 refineries, far less in number compared to the US with its 137 operating refineries as of January 2015 (Nalule, 2018). Investment in petroleum refineries which have been embraced by the US and other developed countries have indeed contributed to their export capacity in refined products. For instance, in 2013, the United States produced 18.9 million barrels per day of refined petroleum products, more than any other country.

Consumption of fossil fuels is also significantly lower in Africa relative to other regions, and reserves are not huge (Ritchie and Roser, 2019), although an important caveat is that individual country consumption and reserves differs markedly. Importantly, between 1990–2005, Africa was responsible for just 2.5% of global cumulative CO_2 emissions from fossil fuels (Mekonnen et al., 2018). There are also international initiatives, notably the United Nations Framework Convention on Climate Change (UNFCCC), notably the Paris Agreement, which aims, amongst other goals, to limit anthropogenic global warming to 1.5°C and "reaffirms the obligations of developed countries to support the efforts of developing country Parties to build clean, climate-resilient futures" (UNFCCC, 2019) through finance, technology and capacity-building support.[2]

Although subsequent sections of this chapter will focus on the role of renewable energy in Africa, it is also worth pointing out other problems with the reducing fossil fuel use in Africa. 60% of international public finance in African energy goes to fossil fuels. In stark contrast, just 18% goes to cleaner alternatives. This leads to concerns that other, typically wealthy countries might be offshoring GHG emissions (Russell, 2018). Indeed, between 2014 and 2016, the "*single biggest public investor in African energy was China. Hailed as a world leader on renewable energy development, 85% of its investments* [US$5 billion a year] *in African energy went into coal, oil and gas*" (Russell, 2018). Germany, another world leading driver of renewables, was the third largest provider of public finance in fossil fuels. One reason underlying this trend in promoting fossil fuel use include countries embarking on the low carbon energy transition attempting to secure energy supplies. Whatever the reasons, this increases the risk of locking in fossil fuel dependence and aggravating attempts to deploy renewables in Africa. It also leads to the increasing risk of fossil-fuel related fiscal burdens, especially in SSA given future population growth coupled with economic growth (Worrall et al., 2018). Critically, without alternatives to fossil fuels, there is a need for African countries to continue to develop and industrialise and tackle energy access issues (Nalule, 2018).

4 Climate Change Challenges in Africa

In the previous section we explored the reliance of fossil fuels in the SSA energy mix. Fossil fuels have been firmly attributed to causing GHG emissions and as such efforts to tackle climate change are, among other initiatives, focused on reducing the reliance of fossil fuels.

[2] Art. 9, 10 and 11 of the Paris Agreement.

There have been various global efforts to tackle climate change. For instance, recently, the 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24) was held in Katowice, Poland from the 2nd–14th December 2018. COP24 involved the most important climate talks and negotiations since the COP21 Paris Agreement reached in 2015. It was at COP21 that world leaders agreed to ensure that global warming stayed below 2 degrees Celsius above pre-industrial levels. Commitments were also made at COP21 to increase financing for climate action and the development of 'national climate plans' by 2020. In the same spirit, COP24 focused on discussions of how to put the 2015 Paris Agreement into practice including how governments will measure, report on and verify their emissions. There are indeed various national, regional and global efforts to address climate change. The global energy challenge in the twenty first century is to bring about a new transition, towards a more sustainable energy system characterised by universal access to energy services, and security and reliability of supply from efficient, low-carbon sources (Bridge et al., 2013). Shifting to a low carbon economy requires taking into consideration the energy challenges faced by various societies. This also should focus on the social, political and economic situation in those regions.

In this section the effects of climate change in SSA will be discussed. On the one hand, according to the Oxford Dictionary, "*climate change is a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels*" (Oxford Dictionary, 2019). The Intergovernmental Panel on Climate Change (IPCC), on the other hand defines climate change as the state of climate that can be identified by changes in the mean and/or the variability by its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). These changes affect the general environment and this in turn not only affects humans but also other species and the biosphere.

The world has experienced events which have been connected to climate change including more frequent wildfires, longer periods of drought and an increase in the number, duration and intensity of tropical storms. It has been noted that Africa is the most vulnerable continent to climate change impacts (Adenle et al., 2017), as it is expected to severely disrupt water and food systems, public health and agricultural livelihoods, not to mention causing enhanced droughts, sea level rise, and changes in the incidence and prevalence of vector-borne disease (Adenle et al., 2017). These projected changes are expected to exacerbate already high levels of food and water insecurity, poverty and poor health and undermine economic development (Adenle et al., 2017). In addition, it has been observed that climate change impacts to the agricultural sector are likely to drive rapid urbanisation in Africa. It has been argued that changes in the climate push people from rural areas to urban areas, and as such urbanisation is seen as an 'escape' from the deteriorating agricultural productivity caused by climate change (Nalule, 2018).

In the Southern African region, for instance, the effects of climate change in the form of frequency of extreme weather events such as droughts and floods are not only evident in sectors such as agriculture and fishery but also present in the energy sector: for instance, countries that rely heavily on large hydropower schemes have indeed been affected with the climate change impacts such as droughts. A case in point is the SADC country of Zambia, which was left facing a 560-megawatt power deficit due to reduced water levels at the Kariba lake reservoir. Indeed, research on the effects of climate change on the Zambezi River Basin points to the fact that an increasingly dry climate will typically reduce hydropower generation for both new and existing plants; as such it has been found necessary to not only seek other alternative energy sources but also to integrate both climate change and upstream development demands into the feasibility studies before investment decisions are made (Nalule, 2018). The negative impact of climate change have therefore made it crucial for the region to ensure the deployment of climate resilient energy assets (Stiles and Murove, 2015: 9). A case in point is the El Niño climate event in Southern Africa which left approximately 21.3 million people in the region requiring emergence assistance due to the drought it has caused since 2015 (United States Agency for International Development (USAID), 2017a). El Niño has deteriorated various sectors such as agriculture, food security, livestock, nutrition and water, sanitation and hygiene conditions in countries such as Lesotho, Madagascar, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe (USAID, 2017a). Basically, El Niño is a naturally occurring phenomenon that involves fluctuations of sea surface temperatures and winds across the equatorial Pacific Ocean. Historically, it raises chances of receiving below average rainfall during the main crop growing season in Southern Africa. Besides Southern Africa, the impacts of climate change have also been evident in East African countries such as Kenya, South Sudan, and Uganda, which have been hit with major drought leading to famine in various parts of these countries (Nalule, 2018). Reflecting on the discussion above, it goes without saying that Africa will experience diverse and severe impacts of climate change, making adaptation essential in these countries. Adaptation refers to the efforts across scales to build resilience and reduce vulnerability to the impacts of climate change (Europa, 2019). However, this faces many varying constraints in different African countries including among others insufficient climate data; limited engagement of adaptation responses to national planning processes and local expertise; failure to make adaptation responses broad so as to not only cover climate change but also climate variability and broader developmental issues; and insufficient adaptation finances. Additionally, there are other challenges facing adaptation in Africa including technical, political, institutional, economic, and social dimensions. For instance, with regard to the technical challenges, it is hard to develop better projections of climate change in African countries (although this is important for adaptation) and this is due to a lack of historical information on weather and climate (Nalule, 2018).

5 Decarbonisation Through the Deployment of Renewables

The development of renewable energy sources is not only essential to tackle energy access challenges in SSA but also recognised as being essential in the decarbonisation of the power sector. Moreover, the need to reduce carbon emissions has not only emphasised the role of renewable energy and the deployment of clean technologies, but it has also triggered scholars to consider other mechanisms such as improved electricity storage as ways of curbing emissions, albeit this depends on the competitiveness of renewable energy against conventional electricity generation.[3]

Typically, by definition, renewable energies are energy sources that are continually replenished by nature and derived directly from the sun (such as thermal, photo-chemical and photo-electric), indirectly from the sun (such as wind, hydropower and photosynthetic energy stored in biomass) or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy) (Ellabban et al., 2014).

There are various advantages of renewable energy sources, for instance, hydro resources have considerable potential to be utilised for power generation. On the other hand, solar and wind energy resources are considered to be excellent for applications such as water pumping, water heating and power generation through centralised schemes, mini-grids and stand-alone systems (Ershad, 2017). Notwithstanding the advantages associated with renewable energy sources, there are some shortcomings relating to the reliance of renewables to expand supply of electricity, which are prone to impacts of climate

[3] For a detailed discussion on electricity storage, see Lazkano et al. (2017). See also Chap. 21 on the role of energy storage in managing the decline of fossil fuels.

change hence hampering hydropower, the intermittency and variability of solar and wind and the risk of over-generation and curtailment (Avila et al., 2017).

At the national level, SSA countries are investing more in renewables. South Africa, a country which meets 80% of its energy needs from coal-fired plants, has plans to diversify its energy production through the deployment of renewables. In this respect, the country has goals to reach 11.5 GW capacity of onshore wind, 8 GW capacity of solar PV and 600 MW capacity of CSP (concentrated solar power) by 2030. In Kenya, there are ambitious plans to diversify the energy sector through the deployment of renewables especially geothermal. At present, Kenya's energy mix is dominated by biomass at 67%; petroleum at 22% and 9% electricity. Kenya is the 8th in the world with respect to geothermal energy production, and there are plans to add 1,745 MW of geothermal generation by 2025. In Zambia, there huge hydro resources and the country is estimated to possess 40% of the water resources in SADC, although Zambia is estimated to have developed only 2,177 MW. Around 6,000 MW of hydro potential is still unexploited and as such this presents a huge renewable energy potential in the country (Zambia Development Agency, 2014). We note that access to energy is a big challenge in many of these countries despite their richness in energy resources. For instance, in Zambia, despite the country's richness in energy resources, only around 22% of the 13.5 million people in Zambia have access to electricity and these are mostly based in rural areas, where it is estimated that 22% are electrified compared to 4.5% in urban areas. This differs from most African countries, where it is usually the urban areas which are highly electrified.[4]

There are indeed various developments at the national level but in this section the focus will be on regional efforts to deploy renewables in SSA.

5.1 SSA Regional Efforts in Renewable Energy

Although the SSA region still faces the challenge of energy poverty, there is potential to meet this challenge by utilising the enormous renewable resources available in the region. There is no doubt that SSA is very rich in renewable energy resources, with solar potential totalling about 10,000 GW; wind potential, totalling about 109 GW, mostly in the coastal countries; geothermal capacity estimated at 15 GW especially in the East African Rift Valley; and exploitable hydropower estimated at about 350 GW mainly located in

[4] For more details on the SSA energy sector at the national level see Nalule (2018).

Angola, Cameroon, Ethiopia, Gabon, and DRC (Avila et al., 2017). Despite these enormous resources and the global commitment to increase the percentage of renewables in the energy mix, there are some basic requirements that need to be fulfilled if the vision is to be attained. These requirements were summarised by Arila et al. in their renewable guide to include among others: policies that incentivise renewable energy deployment; enabling legal frameworks; innovative financing mechanisms; and electricity supply strategies that prioritise the diversity of resources such as dispatchable renewables (Avila et al., 2017).

At a regional level, there should be a legal basis for the development of the energy sector and in this respect renewables. Typically, treaties are the legal basis for regional cooperation in the development of the different energy sectors including the renewable energy sector. The SADC Treaty for instance under Chapter seven provides for the different areas of regional cooperation, amongst which is cooperation in infrastructure and environment.[5] It is worth noting that the SADC Treaty does not expressly make mention of regional cooperation in the energy sector or specifically the renewable energy sector. Nevertheless, this falls under infrastructure, which is expressly mentioned in the Treaty. Comparatively, the Economic Community of West African States (ECOWAS) Treaty under Chapter V expressly mentions the need for cooperation in the energy sector and environment.[6] Whereas the ECOWAS Treaty goes ahead to mention the energy sector, it does not however make specific reference to renewables. These treaties are backed by the various energy protocols which detail cooperation in the energy sector at a regional level. A case in point is the ECOWAS Energy Protocol which is elaborative with respect to the governance of the energy sector at the regional level.

Besides the various Regional Economic Communities (RECs) Treaties and energy protocols, there are other instruments that have an impact on not only the renewable energy sector but energy in general. These take the form of master plans and other regional programmes. In SADC, for instance, the Energy Sector Plan (ESP), which is under the auspices of the SADC Regional Infrastructure Development Master Plan, is intended to address four key strategic objectives including ensuring energy security, improving access to modern energy services, tapping the abundant energy resources, and achieving financial investment and environmental sustainability (Nalule, 2018). One of the sectors covered by the ESP includes renewable energy and energy efficiency. Furthermore, in SADC, besides the master plan there have been an

[5] Article 21 (3) (a) (b) of the SADC Treaty.

[6] Article 29 of the ECOWAS Treaty.

implementation of programmes in the renewable energy sector in line with the SADC Energy Protocol including the following: the Energy Sector Plan of the SADC Regional Infrastructure Development Master Plan (REASAP, 2012); the Regional Energy Access Strategy and Action Plan (REASAP, 2012); the Renewable Energy and Energy Efficiency Strategy & Action Plan (REEESAP 2016–2030); the Programme for Biomass Energy Conservation (ProBEC); and the United Nations Development Programme-supported Financing Energy Services for Small-Scale Energy Users Project (SADC, 2016: 55). In ECOWAS, besides the Energy Protocol and the Treaty, the ECOWAS/UEMOA White Paper on access to energy services for populations in rural and peri-urban areas was adopted in 2006, and this encourages the use of renewable energy in reaching the electrification goals (ECOWAS, 2019).

5.2 Institutions

Besides the establishment of various laws and policies, efforts to mainstream renewable energy and energy efficiency (RE & EE) have been experienced in SSA at the regional level through the establishment of regional centres. There is no doubt that SSA REC through their various activities in the renewable energy sector aim at meeting the objectives of the UNs Sustainable Energy for All initiatives. The establishment of RE & EE regional centres indeed follows the successful establishment of regional power pools such as the Southern African Power Pool (SAPP) and the Eastern African Power Pool (EAPP) in Southern and Eastern Africa, respectively. Whereas regional power pools are mostly concerned with power trading, the RE & EE centres are mostly concerned with the promotion of RE & EE technologies and the development of markets. This is envisaged through sharing information and best practices; developing sound policy, regulatory, and legal frameworks; and building the capacity within the member states of RECs concerned. These centres are at different stages of development with some RECs such as ECOWAS having functional institutions and others such as EAC and SADC being in the preparatory stages of establishing these institutions. In West Africa, the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) legally came into existence by the adoption of Regulation C/REG 23/11/08 in 2008 at the 61st Session of ECOWAS Council of Ministers—and the secretariat of the centre was established in Praia, Cape Verde in 2010 (ECOWAS, 2019).

Although we note that in West Africa the renewable centre has been in existence for more than a decade, in East and Southern Africa, preparations are still underway to establish the regional renewable energy centres. In EAC, for instance, the East African Centre for Renewable Energy and Energy Efficiency (EACREE) was approved during the 33rd Meeting of Council of Ministers held on 29 February 2016. In fact, Makerere University College of Engineering, Art, Design and Technology (CEDAT) was designated as a Centre of Excellence for EACREE. In Southern Africa, the establishment of the SADC Centre for Renewable Energy and Energy Efficiency (SACREE) was approved by the SADC energy ministers on 24 July 2015.

Whereas the objectives of RE & EE centres are promising, it is imperative to note that these will not be achieved by the mere establishment of these centres. There is a need to strengthen not only regional institutions such as regional regulator associations, but also to establish and strengthen national institutions (SADC, n.d.: 35). These are necessary to adopt and implement regional RE & EE projects. However, we note that not all countries are at the same level of establishing the necessary institutions. In SADC for instance, the Regional Electricity Regulatory Association (RERA) is comprised of only 12 Regulatory Agencies implying that three SADC member states have not yet set up national regulatory authorities. Moreover, in order to achieve regional renewable energy targets, there is a need to establish renewable energy agencies and national frameworks for RE in all member states of various RECs (SADC, n.d.: 35).

Due to the various challenges in different countries such as political instability, lack of technical expertise, and financial constraints, SSA RECs are facing discrepancies in the development of RE policies and frameworks at the national level. Taking the example of SADC, South Africa seems to be a step ahead when it comes to RE national policies. For instance, in 2011 the Department of Energy launched the Renewable Energy Independent Power Producer Procurement Program (REIPPP or REI4P) and this is used to tender large-scale installation including technologies such as solar PV, onshore wind, small hydro, landfill gas, and biomass (SADC, n.d.). There are therefore various challenges when it comes to implementing both regional policies and institutional mechanisms aimed at promoting the development of renewable energy as a mechanism of tackling energy access and climate change in SSA.

5.3 Energy Efficiency in SSA

A discussion on renewable energy brings into play the issue of energy efficiency. Generally, the global energy consumption is on the increase in many countries, leading not only to increased local air pollution but also GHG emissions. Energy efficiency and various technological advancements in the energy sector are considered as some of the available options for the reduction of carbon emissions. Moreover, energy efficiency is also considered as a complement of renewable energy—considering that the reduction of energy demand through energy efficiency is capable of improving the financial feasibility of renewable energy options (SADC, 2015).

Although there are common challenges faced by both the developed and developing countries as regards the enhancement of energy efficiency, there are some challenges which are unique to SSA countries. These include, lack of local trained workforce; poor regulatory environment and governance; and lack of access to financing for energy efficiency projects. Notwithstanding the challenges encountered in employing energy efficient techniques, many governments and firms around the world have adopted policies and programs to capture the benefits that accrue from energy efficiency. In SSA, several countries have employed different energy efficiency activities including basic Compact Fluorescent Lamps (CFL) replacement programs. In the SADC region, over ten-member states have instituted CFL replacement programs (SADC, 2015). Other initiatives include solar water heating; demand market participation; standards and labelling; hot water load control; awareness programs; and energy audits in the industrial and building sectors. Ghana, for instance, introduced a programme for labelling appliances, aimed at revealing to the consumers the energy consumption and efficiency of the product. These efforts together with the regulatory framework have led to an estimated peak energy savings of over 120 mega- watts (MW). Additionally, the programme has saved the country USD 105 million in generation investment and reducing carbon dioxide emissions by over 11,000 tons annually (USAID, 2017b). In South Africa, the establishment of energy efficiency incentive programs by Eskom led to the saving of over three gigawatts of total cumulative energy (USAID, 2017b). In Namibia, in an endeavour to increase research in energy efficiency, the Department of Civil Engineering built a demonstration and research house, where 60–70% of energy is saved in the residential building through thermal envelope, air tightness, and sub-soil heat exchangers (SADC, n.d.: 42). Mauritius, on the other hand, instituted a National Energy Efficiency Programme. Improved cook stove programs are also being embraced in various SSA countries as a form of energy efficiency: In the SADC region for instance, all the countries except Mauritius and Seychelles have programs aimed at increasing the use of energy efficient cook stoves (SADC, 2015).

In terms of regional efforts, various institutions including the SAPP in SADC have played a big role in promoting energy efficiency including developing specific programs for CFL replacement and initiating an expanded Energy Efficiency Framework. The Framework covers four technologies including CLFs, Commercial lighting retrofits, solar water heating, and distribution transformer retrofits. Additionally, in the SADC region, there are more than five national utilities which, on the basis of the SAPP initiative, developed demand-side management (DSM) on their own (SADC, 2015). In terms of energy intensity (this is used as a measure of energy efficiency of an economy), some countries are doing better than others, for instance in the SADC region, the DRC, Mozambique, and Zimbabwe have the highest, at 19.1, 17.9, and 17.5 Megajoules, respectively (SADC, 2015). Due to the employment of energy efficiency in the SADC region, there was a demand energy reduction of 4500 MW by the end of 2015 (SADC, 2016).

5.4 Movement to Electric Vehicles

The transport sector is one of the largest contributors of GHG emissions and this has necessitated steps to find alternative transport thus leading to the introduction of e-transport. In the EU there is an ambitious target to reduce the use of internal combustion engine vehicles by 50% by 2030. Further to this, the alternative fuels directive encourages Member States to develop systems which enable EVs to feed power back into the grid.

With respect to Africa, there are no ambitious plans and not much progress has been made in the deployment of EVs as is the case in Europe. However, EVs have made their way in countries such as South Africa, Kenya, Madagascar and Zimbabwe. In South Africa, electric cars were introduced by Nissan Leaf in 2014. BMW later also entered the market introducing its i3 and i8 brands. Jaguar Land Rover also has plans to enter the SA electric vehicle market. The brand in partnership with electric vehicle charging authority GridCars, and with a R30-million infrastructure investment- plans to invest in EV infrastructure including setting up 82 new public charging stations in the country's major hubs and along frequently-travelled holiday routes (Jaguar, 2019). In Kenya, people are embracing second hand EVs and close to 100 units have been imported, mostly Nissan Leafs. There are plans to grow an all-electric fleet (Nissan Leafs) to 200 by 2020 (Nopia, 2019). Used Nissan Leafs EVs are also common in Zimbabwe and these are sourced from Japan. The country also has electric motorbikes mostly from the Chinese market. Nevertheless, on a general basis, Zimbabwe generally has a small vehicle market with annual new gas/diesel sales of under 5,000. In Madagascar, EVs were introduced in 2015 with the arrival of two Chinese EVs, the BAIC EV-Series and the BYD

Qin PHEV (CleanTechnica, 2018). Additionally, in Uganda, there is potential and support for EV. In this respect, Kiira Motors Corporation (KMC) an Automotive Manufacturing Company was incorporated by the Government of Uganda and Makerere University with the main aim of championing value addition in the Domestic Automotive Industry. In 2011, the company designed Africa's first electric car, and this was followed by its first hybrid car in 2014 and a solar bus in 2016. The electric car, under the Kiira EV Smack is a 5-seater front-wheel drive sedan with a traction motor powered by a rechargeable battery bank and an internal combustion engine-based generator (KMC, 2019a); the Kiira EV is Africa's first electric vehicle. It employs a simple battery electric vehicle powertrain consisting of an Energy storage bank, energy converter and an electric motor (KMC, 2019a). It is powered by electricity which is stored in the battery bank through repetitive charging. The solar bus is under 'the Kayoola bus concept', the bus relies on lithium-ion batteries to power an electric motor that is coupled to a 2-speed pneumatic shift transmission (KMC, 2019b).

6 Conclusions

Renewable energy is accepted not only as a solution to energy access challenges but also to climate change. However, as discussed in the sections above, SSA countries are not ready to bid farewell to fossil fuels as these energy sources still have a significant role to play in not only tackling energy access challenges but also in ensuring the economic development of SSA countries. However, given the negative impacts of fossil fuels to the environment, SSA countries should make efforts to mitigate these effects by among others deploying clean technologies.

With more investments in clean energy and reforms in the energy laws, SSA is expected to transition to a low a carbon economy. However, this should not be expected to happen at the same rate as the developed regions, such as those in Europe, as such global efforts to decarbonise have to take into consideration the differences not only in economic development but also the geographic and social dimensions of various countries. Nevertheless, there are efforts in SSA to not only switch to renewables in power generation but also to move to e-transport. Such initiatives are what will help drive SSA forward in the low-carbon energy transition, although it is not without challenges. Additionally, global discussions on energy transition, especially a transition to a low carbon economy, have not placed significant focus on what practical steps are required for developing countries to achieve this transition.

Nevertheless, we have seen incidences where regional organisations compromise their targets to accommodate countries that are heavily reliant on fossil fuels. The EU, although a champion of the transition to a low carbon economy, is a good example of that especially with respect to its patience and compromise to Poland, a country heavily reliant on coal. This highlights the reality of low carbon transitions. With respect to SSA regional organisations, there have been regional efforts to shift to low carbon economies and these are supported in turn at the national level as countries are embracing renewable energy and energy efficiency. Nevertheless, the enormous energy access challenges in SSA makes us question the practicability of saying goodbye to fossil fuels when over 200 million people still rely on inefficient forms of energy such as firewood and candles for cooking and lighting, respectively.

In conclusion therefore, it is imperative to understand energy transition as a progressive process which cannot happen on a global level but rather differs depending on the country and region concerned. Technological advancement and the level of economic development of a country also plays a big role in energy transition. For instance, in the EU countries are moving towards smart grids, smart meters and electric vehicles. These are all enabled by the technological advancement of these countries and also due to the available investments; however, a country like Malawi in Southern Africa or Uganda in East Africa cannot jump from firewood to smart grids or electric cars—energy transition evolves with social and economic advancements and as such bidding farewell to fossil fuels should take into consideration the energy challenges of different countries and also focus on applying justice in the movement to a low carbon future .

References

Adenle, A.A., Ford, J.D., Morton, J., Twomlow, S., Alverson, K., Cattaneo, A., Cervigni, R., Kurukulasuriya, P., Huq, S., Helfgott, A. and Ebinger, J.O. 2017. Managing Climate Change Risks in Africa-A Global Perspective. *Ecological Economics* 141: 190–201.

African Development Bank Group. 2019. The PIDA Energy Vision. http://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/PIDA%20brief%20Energy.pdf.

Avila, N., Carvallo, J.P., Shaw, B. and Kammen, D.M. 2017. The Energy Challenge in Sub-Saharan Africa: A Guide for Advocates and Policy Makers. https://www.oxfamamerica.org/static/media/files/oxfam-RAEL-energySSA-pt1.pdf.

Bouzarovski, S., 2009. East-Central Europe's Changing Energy Landscapes: A Place for Geography. *Area* 41(4): 452–463.

BP. 2017. Statistical Review of World Energy, 2017. https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf.

BP. 2018. BP Energy Outlook: 2018 Edition. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2018.pdf.

Bridge, G., Bouzarovski, S., Bradshaw, M. and Eyre, N., 2013. Geographies of Energy Transition: Space, Place and the Low-Carbon Economy. *Energy Policy* 53: 331–340.

Bulkeley, H., Broto, V.C., Hodson, M. and Marvin, S. (Eds.). 2010. *Cities and Low Carbon Transitions*. Routledge.

CleanTechnica. 2018. Electric Car Sales in Emerging EV Markets—Chapter 1: Africa, November 24, 2018. https://cleantechnica.com/2018/11/24/electric-car-sales-in-emerging-ev-markets/.

ECOWAS Centre for Renewable Energy and Energy Efficiency. 2019. Overview of ECREEE. http://www.ecreee.org/page/overview-ecreee.

Ellabban, O., Abu-Rub, H. and Blaabjerg, F. 2014. Renewable Energy Resources: Current Status, Future Prospects and Their Enabling Technology. *Renewable and Sustainable Energy Reviews* 39: 748–764.

Ershad, A.M. 2017. Review Article: Institutional and Policy Assessment of Renewable Energy Sector in Afghanistan. *Journal of Renewable Energy* 2017(5723152).

Euractiv. 2018. EU Eights 'Derogation' for Poland in Bid to Phase Out Coal, December 17, 2018. https://www.euractiv.com/section/electricity/news/eu-weighs-derogation-for-poland-in-bid-to-phase-out-coal/.

Europa. 2019. Adaptation to Climate Change. https://ec.europa.eu/clima/policies/adaptation_en.

Heffron, R.J. and McCauley, D., 2018. What is the 'Just Transition'?. *Geoforum* 88: 74–77.

Intergovernmental Panel on Climate Change (IPCC). 2007. AR4 Climate Change 2007: Synthesis Report. https://www.ipcc.ch/report/ar4/syr/.

International Energy Agency (IEA). 2014. Special Report: World Energy Investment Outlook, 2014. https://www.iea.org/publications/freepublications/publication/WEIO2014.pdf.

International Energy Agency (IEA). 2019. Coal. https://www.iea.org/topics/coal/.

International Renewable Energy Agency. 2018. Energy Transition. https://www.irena.org/energytransition.

Jaguar. 2019. Jaguar Launches EV Charging and Powerway Network in South Africa. https://www.jaguar.co.za/electrification/jaguar-powerway.html.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H. and Rehner, R. 2016. Energy Justice: A Conceptual Review. *Energy Research & Social Science* 11: 174–182.

Kiira Motors Corporation. 2019a. Kiira EV Smack. http://kiiramotors.com/vehicles/kiira-ev-smack/.

Kiira Motors Corporation. 2019b. Kayoola Solar Bus. http://kiiramotors.com/vehicles/kayoola-solar-bus/.

Lazkano, I., Nøstbakken, L. and Pelli, M. 2017. From Fossil Fuels to Renewables: The Role of Electricity Storage. *European Economic Review* 99(C): 113–129

Leal-Arcas, R., Peykova, M., Nalule, V. and Kara, P. 2019. Decarbonizing the Energy Sector. *Michigan State Journal of Animal and Natural Resource Law*.

Mekonnen, A., Damte, A., Gujba, H., Gebreegziabher, Z., Mulugetta, Y. and Deribe, R. 2018. Fossil Fuels in Africa in the Context of Carbon Constrained Future—Presentation for ClimDeva. https://www.uneca.org/sites/default/files/uploaded-documents/Climate/CCDA1/ccda1_topic3.2_4._ccda-1_presentation_fossil_fuels_africa.pdf.

Mukheibir, P., 2017. Possible Climate Change Impacts on Large Hydroelectricity Schemes in Southern Africa. *Journal of Energy in Southern Africa* 18(1): 4–9.

Nalule, V.R., 2018. *Energy Poverty and Access Challenges in Sub-Saharan Africa: The Role of Regionalism*. Springer.

Niamir, L., Filatova, T., Voinov, A. and Bressers, H. 2018. Transition to Low-Carbon Economy: Assessing Cumulative Impacts of Individual Behavioral Changes. *Energy policy* 118: 325–345.

Nopia. 2019. Home. https://nopiaride.com/.

Oxford Dictionary. 2019. https://en.oxforddictionaries.com/definition/transition.

Podobnik, B. 2006. *Global Energy Shifts: Fostering Sustainability in a Turbulent Age*. The Energy and Resources Institute, TERI Press.

Ritchie, H. and Roser, M. 2019. Fossil Fuels—Empirical View. Our World in Data Report. https://ourworldindata.org/fossil-fuels.

Russell, R. 2018. Fossil Fuels Dominate African Energy Investment, September 4, 2018. https://www.dw.com/en/fossil-fuels-dominate-african-energy-investment/a-45290562.

SADC REESAP. 2012. Renewable Energy and Energy Efficiency Strategy and Action Plan.

South African Development Community (SADC). 2015. SADC Renewable Energy and Energy Efficiency Status Report 2015. http://www.ren21.net/wp-content/uploads/2015/10/REN21_SADC_Report_web.pdf.

South African Development Community (SADC). 2016. Energy Monitor 2016: Baseline study of the SADC Energy Sector. https://www.sadc.int/files/1514/7496/8401/SADC_Energy_Monitor_2016.pdf.

South African Development Community (SADC). n.d. Renewable Energy & Energy Efficiency Strategy & Action Plan for the Southern African Development Community. https://sadc-energy.sardc.net/attachments/article/351/Policy_brief_on_energy_efficiency.pdf. Page 35.

Silver, J. and Marvin, S. 2018. Examining Urban Africa's Low Carbon and Energy Transition Pathways. In: Luque-Ayala, A., Marvin, S. and Bulkeley, H. (Eds.) *Rethinking Urban Transitions: Politics in the Low Carbon City*. Routledge, p. 46.

Smil, V. 2010. *Energy Transitions: History, Requirements, Prospects*. ABC-CLIO.

Sovacool, B.K. and Dworkin, M.H., 2015. Energy Justice: Conceptual Insights and Practical Applications. *Applied Energy* 142: 435–444.
Stiles, G. and Murove, C. 2015. SADC Renewable Energy and Energy Efficiency Status Report 2015. http://www.ren21.net/wp-content/uploads/2015/10/REN21_SADC_Report_web.pdf.
United Nations Foundation. 2019. Achieving Universal Energy Access. http://www.unfoundation.org/what-we-do/issues/energy-and-climate/clean-energy-development.html.
United Nations Framework Convention on Climate Change. 2019. What is the Paris Agreement? https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement.
United States Agency for International Development (USAID). 2017a. Southern Africa Drought, Fact Sheet, January 2017. https://scms.usaid.gov/sites/default/files/documents/1866/southern_africa_dr_fs04_01-30-2017.pdf. Last visited on 8 May 2017.
United States Agency for International Development (USAID). 2017b. Examining Energy Efficiency Issues in Sub-Saharan Africa. https://www.usaid.gov/power-africa/newsletter/dec2014/smarter-power-in-africa.
Willsher, K. 2018. Gilets Jaunes Protests in France to Continue Despite Fuel Tax U-turn. *The Guardian Newspaper*, Tuesday 4, 2018. https://www.theguardian.com/world/2018/dec/04/french-government-to-suspend-fuel-tax-increase-say-reports.
Wood, G. 2018. Policy Risk, Politics and Low Carbon Energy. In: Considine, J.L. and Paik, K-W.(Eds.) *The Handbook of Energy Politics*. Edward Elgar.
Worrall, L., Whitley, S. and Scott, A. 2018. Reforming Africa's Fossil Fuel Subsidies. International Centre for Trade and Sustainable Development. *Bridges Africa* 7(3). April 24, 2018. https://www.ictsd.org/bridges-news/bridges-africa/news/reforming-africa%E2%80%99s-fossil-fuel-subsidies.
Zambia Development Agency. 2014. Zambia Energy Sector Profile, September 2014. https://www.google.com/search?q=Zambia+Development+Agency%3A+Zambia+Energy+Sector+Profile%2C+September%2C+2014.&rlz=1C1NHXL_enGB699GB699&oq=Zambia+Development+Agency%3A+Zambia+Energy+Sector+Profile%2C+September%2C+2014.&aqs=chrome.69i57.565j0j4&sourceid=chrome&ie=UTF-8.

11

On the New Paradigm of International Energy Development: Risks and Challenges for Russia and the World on the Way to the Low-Carbon Future

Andrey Konoplyanik

1 Past and Modern Paradigms of International Energy

This chapter[1,2] aims to analyse an objective character of the long-lasting ripening of the preconditions for the shift in the key, from this author's view, paradigm that has been triggering international energy development in the past till nowadays (the perception of 'peak energy supply') to a totally opposite paradigm of international energy development in the current and already near future (the perception of 'peak energy demand'). It appears that the tipping point for such a paradigm shift has already been passed, at least mentally, within the professional community of energy economists (both academic and business) and part of political establishment (and what is more important—a decision-making part in most cases) predominantly in some developed market

[1] Views expressed in this chapter do not necessarily reflect (may/should reflect) and/or coincide (may/should be consistent) with the official position of Gazprom Group (incl. Gazprom JSC and/or Gazprom export LLC), its stockholders and/or its/their affiliated persons, or any Russian official authority, and are the full personal responsibility of the author of this chapter.

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economies. Although a majority of people (inspired through mass media by climatologists, especially ‘climate alarmists’, and ‘greens’) couple this mental shift with the climate agenda, namely the Paris Agreement of 2015 (COP-21), this author argues that the preconditions of this shift refer to much earlier international/global developments from almost half a century ago.

The key reason for pushing the international energy economy towards this shift appears in the early 1970 with the radical increase in international oil prices which in turn reflected and was the reaction to the accumulated antagonisms of the institutional structure of the international oil industry since its organisation in 1928 on the basis and principles of the ‘Achnacarry Agreement’ (Bushuev et al., 2013; Chevalier, 1973; Konoplyanik, 2013a, b, c; Yergin, 1991). The combined effects of the OPEC oil embargo and its oil price increase of 1973 created (like a ‘butterfly effect’) the critical mass to trigger adaptation of the world economy to the new international order.

The following ‘domino effects’ of adaptation of the world economy to the new oil price levels and to the shift of pricing mechanisms (price establishment) from IOC to OPEC (revolutionary changes of the 1970s), created, in a few decades (an objective high inertia of investment-based institutional and business decisions), accumulated structural effects on the world economy in its shift from being ‘energy-wasteful’ prior to the 1970s to an increasingly ‘energy-efficient’ type today. It is only based on this development with diminishment of the GDP energy intensity worldwide (at least in majority of the countries with noticeable energy demand and state of economic development), that the climate agenda, concentrated in the provisions of the Paris Agreement, has added another dimension to the trend, by increasing significance from now onwards such partial productive factor as ‘carbon intensity’, in the same way that ‘energy intensity’ has been a dominant issue since the early 1970s.

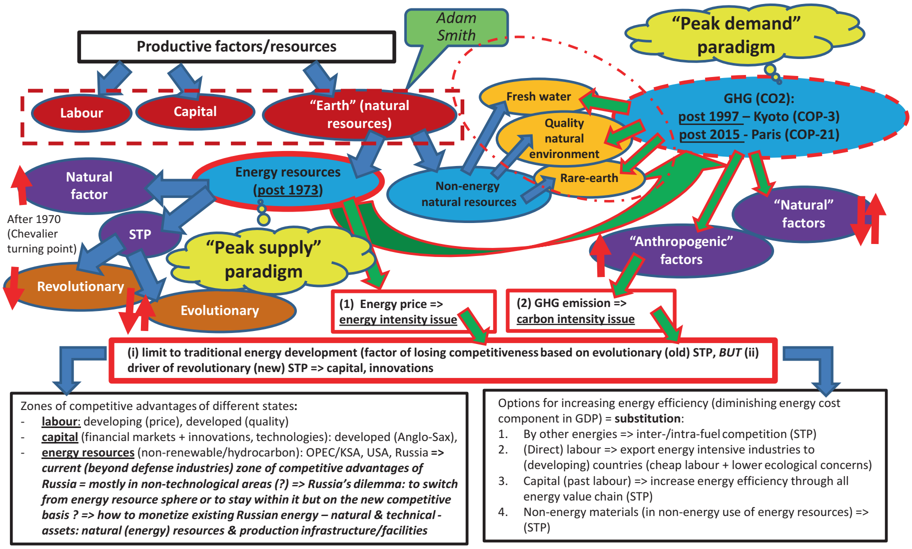
Within post-1970s developments, positive environmental changes were considered until recently as a consequence of the secondary order that resulted from improvements in energy efficiency, the latter viewed as the primary/key priority, although nowadays it seems the climate agenda has topped the priorities in a number/most of developed market economies thus merging a longer historical demand for improvements in energy efficiency with the more recent, but now more and more urgent, demand for low-carbon energy development to speed up the diminishment of negative consequences from energy development on the global environment.

As the shift from an energy-wasteful to energy-efficient economy creates risks and challenges for different states due to their competitive advantages/niches under ‘old’ and ‘new’ economic/institutional structures globally and nationally, the same is/will be the story with low-carbon development. Some countries will see the shift to the low-carbon future as a loss of their existing international competitive advantages. Others will see it, in contrast, as an opportunity to gain new competitive advantages by creating new national competences (if they—their national institutional structures—are ready for timely developing of such competences) and to grasp/win new competitive niches in the new growing (and/or to appear and to grow in the coming future) innovative markets being developed with the transition of the global economy to the low-carbon development path.

This set of issues will be analysed in this chapter with particular attention to the Russian Federation.

1.1 Political Economy of International Energy: Concepts and Definitions

First, one needs to sort through the concepts and definitions that will be later used in this chapter (Fig. 11.1). Following the classification by Adam Smith, the basic productive resources (productive factors) are labour, capital, and



Source: A. Konoplyanik

Fig. 11.1 The political economy of world energy: productive factors, inter-factorial competition and STP in energy and the current competitive niche of Russia. Similarity of two global responses to global challenges: past to energy intensity challenge (1970+) & current/future to carbon intensity challenge (2010+)

land ("Earth"). Modifying this classification, one may split the 'land (Earth)' factor (natural resources) into non-energy and energy resources. The latter deserves some special attention, and it is their independent analysis and study (as separated into an independent group of productive factors for this purpose) that have won so much interest since the early 1970s due to the oil crises that precipitated the oil price shocks and multiple comprehensive following effects ('domino effects') throughout multiple spheres of the global economy.

Energy as a productive resource (i.e. its share in the social product) is influenced by two factors: scientific and technical progress (STP) and the natural factor (the influence of Mother Nature). Up to the turn of the 1960s/1970s, the latter used to work towards reducing both the average and marginal costs of production in the global oil and gas industry, at least at the prospecting, exploration and production stages, and since that turn—towards their growth[3] (Chevalier, 1973, 1975). The STP factor, which always aims to move the cost curve downwards, consists of the evolutionary and the revolutionary components (see Fig. 11.1—red arrows show the direction of influence of different factors).

Until the early 1970s, due to the cheap and abundant supply, foremost, of Middle Eastern oil meeting the growing demand for liquid fuels, energy was a stimulator of economic growth: the cost of energy intensity in GDP (energy intensity in value/monetary terms), or the share of energy as a productive factor among other productive factors, remained low. Starting from 1973, after the first major (four-fold)[4] hike in oil prices resulting in a significant increase of energy prices and the share of the energy component in social costs, energy (energy as productive factor or energy intensity in value terms) turned into a suppressor of economic growth. In response, the world economy, acting within the framework of the supply peak theory, generated a system of initial decisions/actions that triggered proliferating chains (long-term cycles) of 'domino effects' with long-lasting investment consequences; these are entailing (have entailed or may entail eventually) a change in the paradigm of international energy development.

The cost of energy intensity of GDP (energy intensity in value/monetary terms) growing everywhere due to increases in energy prices, put a limit to traditional (energy wasteful) economic development, since it became a factor

[3] This author called it the 'Chevalier's Fracture/Turning Point' in reference to the French energy economist who first, according to this author's knowledge, provided this thesis at least as a hypothesis (see more on this further below).

[4] Meanwhile, the hike in oil prices started earlier (it dates back to 1969 when OPEC countries finally forced the companies of International Oil Cartel to step-by-step slightly increase posted prices), and the first oil crisis, as argued by Chevalier (1973, 1975), took place in 1970.

in the loss of competitiveness based on 'old-type' (evolutionary) STP. At the same time, it also became the driver for the revolutionary ('new-type') STP via the inflow of capital to the innovative development of energy industries on both the demand side (transition from energy-wasteful to energy-saving economic development) and supply side (presented by competitive innovative technologies to master the previously unprofitable energy resources; the latter could be both new energy resources in old and/or new production areas or old energy resources in new production areas).

As a problem concerning a particular natural resource aggravates (usually due to its future or emerging deficit), the attention of the international (scientific and/or civil) public to it may heighten and, the same as energy (the energy factor of production) in its time, it may be singled out as an independent subject of study, analysis and public attention. For example, fresh water is turning (has turned already?) today into such a stand-alone natural resource, a zone of independent specific attention, as the global risk of its deficiency keeps growing (maturing) against the prevailing tenor of technology. In some regions of the globe, the shortage of fresh water is already an established fact and major problem. For quite some time too, a special concern has been strengthening with respect to the purity of the atmosphere (as estimated through emissions of CO_2 and/or other greenhouse gases) or in a broader sense, to the purity of the human environment (the totality of natural resources surrounding a human being, treated as a comfortable environment and sustainable development for humanity). The rise of microelectronics and renewables increases their profile in the global agenda despite potential concern of the availability of rare-earth minerals/natural resources (see Fig. 11.1).

Two groups of successive consequences in regard to how the global economy responds to the rise of energy intensity of GDP (in monetary terms) can be identified. At first, an accumulated material effect of different actions (reactions) of the world economy, within a few recent decades, in response to the rise in oil prices and the multiple 'domino effects' it triggered. This resulted primarily in diminishing global (and fully breaking in some developed economies) the correlation between energy development and economic growth. Secondly, collective solutions were added to them somewhat later, aimed at overcoming other drastic consequences for the global economy, those aggravating (accelerating) the transition of world energy industry to its new development paradigm.

A collective decision most important in its consequences for the global energy industry is the Paris Climate Agreement (COP-21) signed at the end of 2015. This introduced the so-called voluntary-compulsory restrictions on CO_2 emissions resulting from human activities. As a result, a new 'meter' with specific attention to it may appear in the system of productive factors by analogy with energy intensity which became specifically attentive since the early 1970 only when it grew in importance due to oil price rises. Now it will be the 'carbon intensity', i.e. specific CO_2 (and/or other GHG) emissions per unit of GDP or a specific product produced (except it will be an 'output' of production activity instead of its 'input' as in case of energy intensity). That indicator may become a key partial measure of the efficiency of production activities for world economic development, the way energy intensity used to be since the 1970s.

The Paris Agreement may have a primary deterrent effect on the further development of traditional energy industries, since in addition to economic incentives that push the economy towards abandoning the traditional energy industries based principally on the development and utilisation of fossil fuels, direct administrative restrictions are added to accelerate such a transition to low-carbon and/or even carbon-free development. This is the key (final) step in awakening mankind to the need to transit to a new paradigm in developing the global energy industry (at least this mental shift has already occurred at least in part of the most economically advanced, under the industrial model of economic development, countries). A change of paradigm (in my system of terms) means a transition from anticipation of peak supply (and from functioning and economic development within that perception) to anticipation of peak demand (and to functioning and economic development within such a new perception).

The question is: what is the optimal trajectory of such a transition and what risks and challenges (promising opportunities) await different countries, including Russia, along it? How can these risks be minimised to an acceptable level? And how can such promising opportunities be capitalised (monetised)?

1.2 Zones of Competitive Advantages of Different Countries: Labour, Capital, Natural Resources

Where are the zones of competitive advantages of different countries? Going by the price of their labour (labour resources), its quality remaining relatively low, developing countries retain such an advantage. To a large extent, that is what caused the global flows of capital after the 1970s in response to the rising oil prices, when energy-intensive industries were actively transferred from the industrialised oil/energy-importing countries to developing countries in order to compensate, at least partially, by direct (and then cheap) labour for the sharply increased energy costs.[5] Industrialised countries continue to maintain a competitive advantage in the market of high-quality labour (the relatively high-priced blue and white collar workers), including the well-organised practice of a 'brain drain' from other countries, a policy made attractive due to the high price of high-quality labour.

As for the market of capital (whether financial-monetary, non-materialised, or innovative—the technological capital, materialised), the industrialised countries of the Anglo-Saxon world still retain their competitive advantage. That is why the consequences of restrictions on entering these markets are so painful for Russia, as other financial markets remain incapable of offering comparable financial alternatives (in terms of price, volume, quality of financial borrowing and other services) (Konoplyanik et al., 2015; Zhukov and Zolina, 2016).

Meanwhile the market of non-renewable energy sources (NRES) such as hydrocarbons is dominated by three groups of states today: OPEC countries (first of all, the Kingdom of Saudi Arabia, or KSA), the United States (US), and the Russian Federation (RF).

OPEC countries have historically been 'strong' on the physical energy market (production/export volumes), and after the price hike of the 1970s and subsequent years, their presence in the global financial markets has strengthened as well via the mechanisms of recycling their petrodollars.[6] These countries have been and remain price-makers on the physical global oil market.

By the early 1970s, the US had lost their dominant role in the global market of physical energy: as predicted by M.K. Hubbert back in 1949–1956 (Hubbert, 1949, 1956), the country had peaked in its oil production in 1970, turning quickly into a net importer of liquid fuel. However, the American 'shale revolution', first in dry shale gas that progressed to 'fat' (wet) gas and then to shale oil has eventually brought the US to its current position of a major player in the global physical oil market, coming second along with OPEC (Saudi Arabia), as the *de facto* second balancing supplier in that market capable of responding quickly to changes in the oil conjecture by respective adjustments of the level of supply. A kind of dualistic system of opposing players in the physical oil market was formed: OPEC countries (and producing

[5] Such transfer of energy-intensive industries to developing, primarily, Asian countries, has predetermined, to some extent, their later economic growth based on the industrialised model of economic growth imported with the corresponding technologies from the industrialised states.

[6] These 'petrodollars recycling' mechanisms differs slightly within two waves of such recycling in two periods of high world oil prices: under the high oil prices of 1970–1980s petrodollars recycling was aimed mostly to the material sphere and under high oil prices of the 2000s and 2010s to the financial sphere (Bushuev et al., 2013; Konoplyanik, 2013a).

states aligning with them either provisionally or steadily as producers of traditional oil, like the members of OPEC-plus lasting agreement), on the one hand, and the US companies producing shale oil, on the other.

However, the latter are not the price makers in the global oil market themselves, unlike the OPEC countries. What shale oil producers are capable of is compensating quickly for certain moves by the price-makers, reacting promptly to production curbs or boosts by the OPEC countries (plus those others to have joined the OPEC pack to hike or suppress the prices) with actions of the opposite final orientation. As OPEC countries (several state-owned companies of these countries) reduce production in a coordinated manner, prices start rising; numerous minor, medium and major shalers are ready to increase their production in response to that price rise; the global supply increases eventually, and prices start falling. The circle gets closed (Konoplyanik, 2014a, 2016a, 2017a: 14–15).

However, the US (more precisely, the largest US financial institutions) are price-setting players (price-makers) in the global 'paper oil' market, thanks to their dominant role in the global financial market, the derivatives market first of all (according to IMEMO RAS specialists of the Energy Research Center (ERC)), 95% of that market is controlled by four groups of the largest US investment banks: JP Morgan Chase, Citibank, Bank of America, and Goldman Sachs (Zhukov, 2011). Note that the development of the market of oil derivatives is, in principle, beneficial for oil exporters. Financial investors are capable to operate with both rising and falling oil prices. However, the analysis still shows them to be more interested in the growth of oil prices than in their fall. There, the interests of oil exporters and financial investors coincide (Kopytin, 2011).

Thus, a unipolar structure is gradually forming in the global oil market, consisting of two segments; in terms of the aggregate presence both these segments feature a growing US dominance with its production companies and financial institutions (Konoplyanik, 2013b, c).

At the same time, the US oil market kept developing, including the formation of the international oil trade (de facto by American oil companies or with their dominance), always parallel and closely connected with the developing US financial market. It was a national market first, but World War I catapulted it almost immediately to the international level, with US financial institutions dominating. It has received additional stimuli for international dominance during World War Two and post-war reconstruction of the global economy. Moreover, the expansion of the international oil trade was based on the American financial system, since that trade lagged temporally in relation to the latter. The chronicle of events was as follows:

- *November 21–26, 1910*: The town of Jekyll Island (US): a meeting of representatives of the then six largest US financial institutions resulted in forming the US Federal Reserve System (US FRS) on December 23, 1913; that meeting precipitated the start of forming the global financial system based on the global dominance of the Anglo-Saxon (mainly American) financial institutions (Prins, 2014);
- *September 17, 1928*: In the Scottish town of Achnacarry: a meeting of the then seven largest oil companies (five American, one English, one English-Dutch), resulted in signing an agreement to form the International Oil Cartel (IOC); that meeting marked the start of forming a global oil supply system based on the dominance of Anglo-Saxon (mainly American) vertically integrated companies (VIOC) (Chevalier, 1973; Yergin, 1991), closely interrelated initially with the relevant financial institutions, primarily US-based.

Russia is not an independent price maker on the physical oil market (except only when teaming with OPEC). Due to its continentality (geographical position with respect to export markets), Russia is not that tightly built into the open system of world oil trade; it is associated more with technologically rigid pipeline supply chains linked to specific, mainly European, consumers.

Thus, the current zone of competitive advantages of the Russian Federation[7] is basically not a zone of technological advantages, but a consequence of the enormous natural wealth of the country. Note that the natural factor per se, the abundant natural NRES is economically both negative (most of the industry resources/reserves reside beyond the Arctic Circle, in remote areas and adverse environmental conditions, distanced far from their consumption centers) and advantageous for our country (the scale effect of multiple large and gigantic (by world standards) deposits working in the country's favour). High individual reserves of separate fields offset the negative side of the 'natural factor' inherent to the Russian oil industry, partly. Ultimately, this results in the relatively low production and transportation costs for NRES targeted to their main markets.

A common feature in the development of large energy industry systems based on developing the NRES, is the deterioration of the natural conditions of their activities with time (beyond 'Chevalier's Turning Point'). That, in its turn, leads to the natural loss of the competitive advantages that Russia features only due to its abundant NRES resources/stocks, unless it is compensated by revolutionary STP achievements.

[7] Outside the sphere of the defense industries and narrow technological advanced undertakings from the manufacturing industries and/or intellectual services.

1.3 Inter-Factor Replacement (of Productive Resources): Lessons Learned for Decarbonisation

How can one respond to the rise in energy prices that entailed a sharp rise in price and share of the energy component in the social costs (GDP energy intensity in monetary terms)? Such reactions may be many-fold, but all of them will be different forms of substitution at the level (within the scope) of productive factors: some productive resources that have become less competitive shall be replaced by others whose competitiveness has increased, though not necessarily due to any targeted measures undertaken to stimulate it.

Within the framework of competition between the various productive resources such a substitution (structural reorganisation, structural changes in the global economy) has taken place repeatedly along the path leading from less expensive to more expensive measures, from simpler to more complex transformations.

The first step in a series of consecutive measures to respond to rising energy prices consists in replacing oil with other energy resources within the framework of the existing tenor of technology, while striving initially to preserve its technological structure. Such substitution took place at the beginning as intra-fuel competition, i.e. replacement of the now expensive oil from OPEC, due to the artificial increase of its price by OPEC states, with oil from other sources outside OPEC. These other sources, being noncommercial under previous low oil prices, managed to achieve acceptable profitability due to increased OPEC oil prices. Existing expectations of import-dependent developed economies that their oil companies would price the newly developed and thus costlier to produce oil below the price established by the then price-making OPEC countries has failed: all oil delivered into international trade was priced on the OPEC-stated level and was equally expensive for consumers non-dependent of its origin. This is why 'inter-fuel' competition has come instead later which is a replacement of expensive oil by other energy resources, e.g. gas, coal, that have become relatively cheaper as end-use products due to technological competition in energy consumption.

Then, paradoxical as it may seem, the step of replacing energy with live labour came (though such a substitution may seem to be a sign of regress for many). That step expressed itself in the transfer of energy-intensive industries from import-dependent industrialised countries characterised by expensive energy and labour to countries of cheap labour, if not cheap energy. That is, a deliberate withdrawal of such industries to the developing countries was taking place. Parallel to that the industrialised countries were solving one more task: as a rule, energy-intensive production processes are environmentally dirty (used to be even more so at the time). Namely, the fight to preserve the clean natural environment evolved in the industrialised countries particularly in the 1970s. That is to say, transnational companies not only solved the task of compensating for the growth of their energy costs by saving on live labour, but also reduced the cost of complying with environmental regulations (installing the cleaning equipment required in the parent countries): in their new host (now developing) countries, such environmental protection requirements had not become relevant yet, and deploying energy-intensive production lines there, dirty by the developed market economies' standards, one could save on the appropriate environmental mitigation equipment.

Note though that when energy-intensive industries were transferred from industrialised to developing countries, the model of industrial development was exported from such industrialised countries to those developing ones, regardless of the actual fitness of such a model for them at the current stage of their development. In particular, such industries, transferred to China, India and other developing countries rich in cheap labour, provided their ensuing economic boost that followed a specific industrial model with all its pluses and minuses, forcing such countries to develop along the trajectory that the industrialised states had taken before them, and to face (and thus be obliged to solve) similar problems.

The next step consists in replacing energy with past labour (capital). The issue now is improving energy efficiency at every step of the energy chain—from mining to end use, with such efficiency to be yielded, first of all, by the achievements of the revolutionary STP (see Fig. 11.1).

It seems that in response to growing concerns regarding 'carbon intensity' of the economy, the states (at least developed market economies) will follow the same path of inter-factors substitution (meaning productive factors, including partial ones to which carbon intensity belongs today like 'energy intensity' previously): first it would (should) be structural substitution followed (in a 'nested doll' manner) by technological improvements, from least to more costly ones, aimed at reaching technological breakthroughs.

1.4 Hubbert's Curves, Hotelling's Rule/Rent, Chevalier's Turning Point

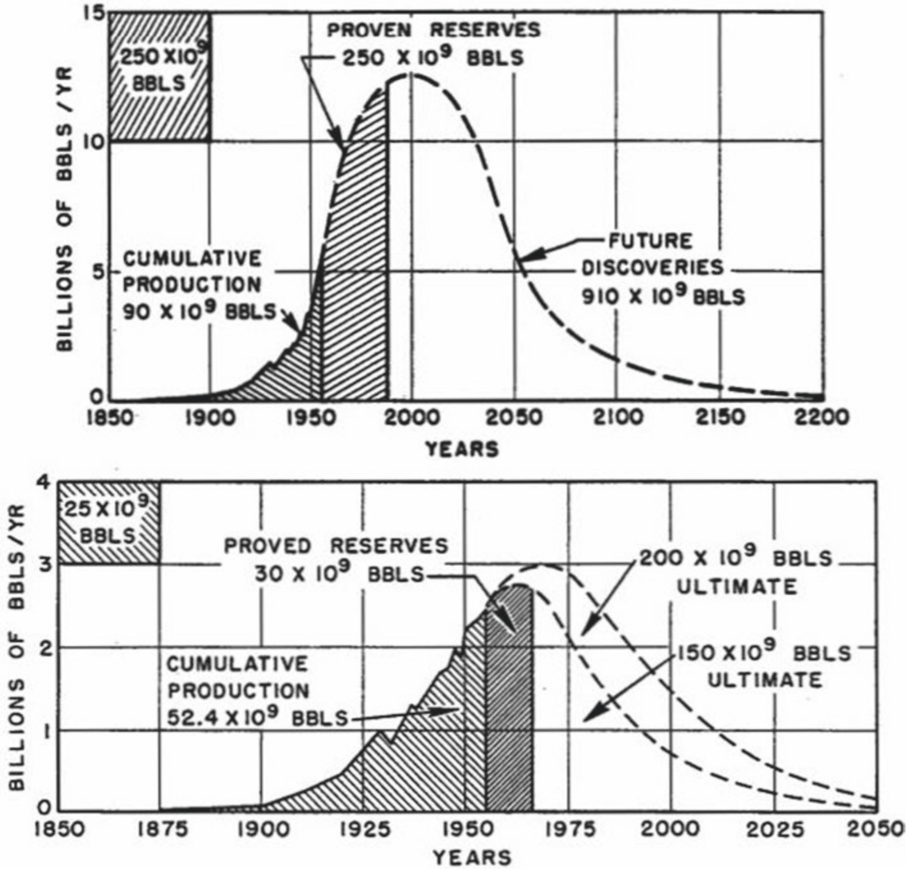
The lay public consciousness allows that the offer of NRES may become limited and somewhat restricted in the future as the energy industries keep developing on this basis. The main assumption underlying the modern energy industry development paradigm follows from the analysis by the three 'classics', whom the current author believes to be the founders of the economic basis of international modern energy industry relying on the use of fossil fuels: M.K. Hubbert, H. Hotelling and J.M. Chevalier. They formulated the three basic principles characterising the paradigm of international energy development based on NRES and determining such development.

First, Hubbert's Curve (Hubbert, 1949, 1956) underlying the peak oil theory. This curve demonstrates that since oil and gas resources are exhaustible (finite), hydrocarbon producers are bound to reach peak production at some point in time with production declining thereafter. That effect stems from the nature of the production time profile for any individual hydrocarbon deposit/field: production growth and retention of its maximum volume (the 'shelf') decrease. Therefore, with time, an ever-increasing share of newly commissioned production capacities within a single oil and gas province, country, group of countries shall strive to compensate for the production decline via existing fields instead of providing further growth (Fig. 11.2).

Different interpretations of the curve are allowed within the framework of two different schools of thought, based on using Hubbert's Curves for the purposes of static (or 'geologist's') vs. dynamic (or 'economist's') modeling. The so-called geologists believe that the resource base available today determines the physical limits to the growth of energy production, with its peak to be reached quite soon. This is a static modeling approach: energy supply is a function of the resource base, depleted as production progresses. Moreover, respective calculations are conducted often either using technically recoverable or proven recoverable reserves though both resource categories are not static within the timeframe. Both calculation techniques are incorrect: the first reflects the current level of technology development only and/or the second limits itself by the current economic situation, thereby neglecting the permanent effect of STP.

The so-called economists believe that if that Hubbert's peak ever comes, it will not happen now (according to this author, at least not during the nearest two investment cycles, the current and the next ones) (Energy Charter, 2007; Konoplyanik, 2004, 2017a), because the peak of the Hubbert's Curve keeps shifting right and upwards due to STP. This is a dynamic modelling approach: energy availability is the function of STP (the result of financing and applying new technologies, that is the function of investment climate), and the resource base that is profitable for development keeps expanding as production proceeds.

As a result of STP (its evolutionary and/or revolutionary branches) and/or changes in the price conjecture, energy resources that used to remain



Source: M. King Hubbert (1956), "Nuclear energy and the fossil fuels." Presented before the Spring Meeting of the Southern District Division of Production American Petroleum Institute Plaza Hotel, San Antonio, Texas March 7-8-9, 1956 // Publication No. 95, Shell Development Company, Exploration and Production Research Division, Houston, Texas, June 1956 (was to be published in "Drilling and Production Practice" (1956) American Petroleum Institute)
Note: upper Hubbert's chart refers to the World, lower chart refers to the USA.
Alternative option in the next remark

Fig. 11.2 Marion King Hubbert (1903–1989) and the "Hubbert's Curve" as applied to US (lower chart) and global (upper chart) oil production from the 1956 perspective

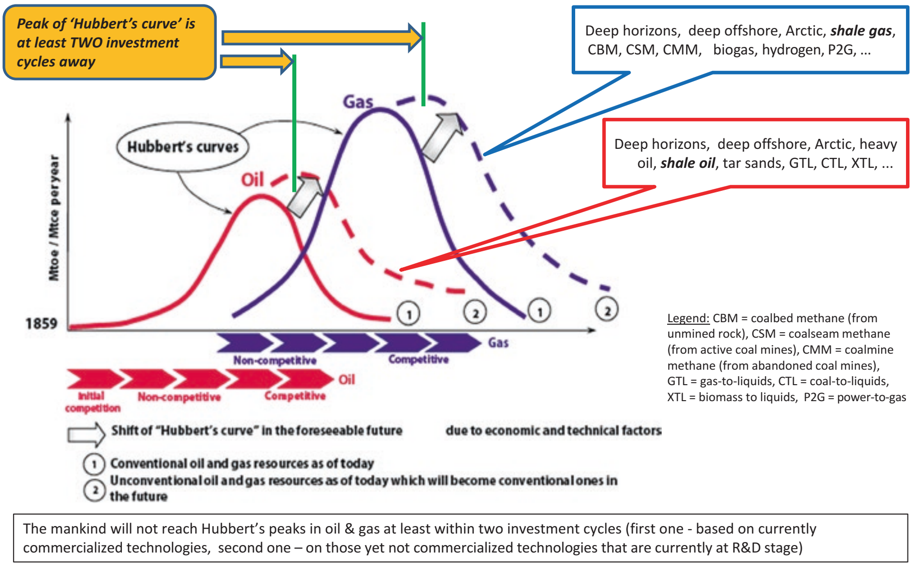
unprofitable for development[8] previously thus staying outside the Hubbert's Curve in the past, now drift under that curve, the area below that zone increases and the peak of the curve shifts right and upwards.

[8] The remaining energy resources are unconventional in the author's terminology: the distinction between traditional and non-traditional resources does not follow the physical and chemical, geological or natural climatic differences, but their final key economic difference according to the actual profitability of developing certain energy resources, under the given economic and political conditions. In other words, the entire set of associated risks of production and delivery/trade shall be taken into account; and it is ultimately the result of the technology applied (the factor of STP) and the price level (the factor of the current economic situation).

So, within the framework of this author's economic interpretation of the Hubbert's Curve (Fig. 11.3), its peak drifts to the right and upwards as the 'unconventional' energy resources (formerly unprofitable for their development and use) become profitable, thus drifting under that curve, and expanding its respective area and shifting the peak of the curve. Meanwhile, even in theory, reaching the peak of the Hubbert's Curve cannot happen before the completion of two global investment cycles: the current one and the one following it.

The current investment cycle is a period of commercialisation of existing technologies in the energy sector within the current tenor of technology (application- and payback-wise). Huge funds are invested by both the businesses and states not only (and not so much) in energy production, transformation and consumption, but in gaining productive means for these purposes (i.e. in the industries associated with energy industries). No rational economic actors still in command of their wits will ignore such funds (or write them off). Therefore, such already invested funds must be and will be monetised (their payback will be ensured) before progressing to new technologies.

Moreover, substantial funds have already been invested by both states and businesses in the investment cycle to follow (i.e. in developing next generation technologies). Namely, this is R&D (which peak into the day after tomorrow



Source: A. Konoplyanik

Fig. 11.3 Economic interpretation of Hubbert's Curves and even beyond, so it makes no sense to guess their contours and even less their commercialisation prospects yet), and especially future applications which provides practical knowledge today about the technologies of tomorrow, to be commercialised and put into practice during the next investment cycle.

Thus, going by the results of such applied R&D, we see which energy technologies and which production processes/technologies (i.e. beyond energy industries) will be commercialised during the next investment cycle. Essentially, such a cycle has started already, since any investment cycle starts with its R&D stage. It sets the investment development inertia (the most rigid one) for the period of the second investment cycle down the whole energy chain from production to end-use. Therefore, as much as the trend described above prevails, we are not at risk of reaching the peak of the Hubbert's Curve for about, say, the next 50 years.

Secondly, there is Hotelling's Rule (Hotelling, 1931), according to which the future value (cost) of NRES in the earth grows over time by the value of bank interest rates (Fig. 11.4). It implies the existence of two types of resource rents when selling NRES on the market: the Ricardian Rent and the Hotelling's Rent (Energy Charter, 2007).

It also follows from here that extracting (monetising) the Hotelling's Rent is not the result of market dominance of an exporting company in the energy market of an importing country due to an allegedly anti-competitive behaviour of such a company (e.g. as the European Commission has been incriminating PJSC Gazprom within the EU gas market). Instead, it stems from a lack of competitive replacement technology (backstop technology) or replacement energy source, or alternative suppliers of such energy resources in the country dependent on its import (see Fig. 11.4). Each such roadblock may be overcome by respective investments, independent of the behaviour of either the exporting country or company, and it is fully dependent on the investment climate and motivational behaviour of the receiving importing country with respect to prospective investors.

In case the host (importing) country takes no such actions, the exporting company of the resource-owning foreign state[9] is fully entitled to extract not only Ricardian rent from the export markets of third countries by selling gas at the price based on 'cost-plus' pricing mechanism, but also to extract the Hotelling's rent as well by selling gas at a price pegged to the cost of its replace-

[9] Especially a state company of the exporting country acting as the economic agent of its sovereign state such as the 'Russian Federation—Gazprom PJSC' conjunction, where RF Law 'On Gas Export' defines Gazprom as a monopoly exporter of Russian pipeline gas.

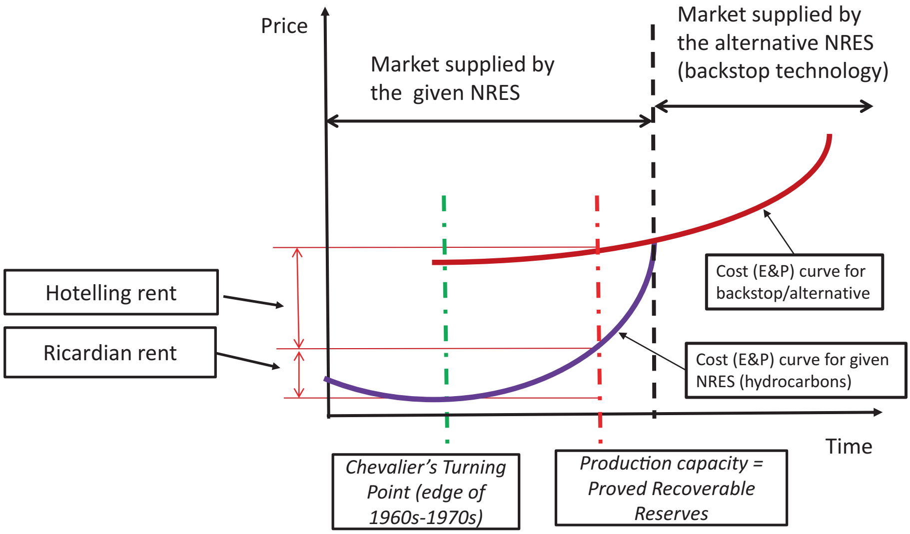


Fig. 11.4 Harold Hotelling (1895–1973) and the "Hotelling's Rule": an economic rule regarding natural resource rent. (Source: A. Konoplyanik based on the work of Hotelling (1931) and chart from Neha (1973))

ment fuel (backstop technology)—at the replacement value—in the market of such a country. Such an economic approach of a sovereign state to extract the maximum monetised (i.e. marketable) resource rent on export (Ricardian rent plus Hotelling's rent), i.e. selling its gas competitively against its substitutes, is protected by such international legal acts as the UN General Assembly Resolution 1803 of December 16, 1962 'Permanent Sovereignty over Natural Resources' and Article 18 'Sovereignty over Energy Resources' of the Energy Charter Treaty of 1994 (entered into force on April 16, 1998) (Energy Charter, 2007).

In combination, both concepts act towards increasing the future cost (value) of NRES in the subsoil over time. However, neither scholar had taken possible restrictions on the demand side into account.

Thirdly, it was J.M. Chevalier who substantiated, at least at the level of theory, the so-called '*turning point*' at the cusp of the 1960s/1970s in the dynamics of marginal and average costs of oil exploration and production in the world (Chevalier, 1975):

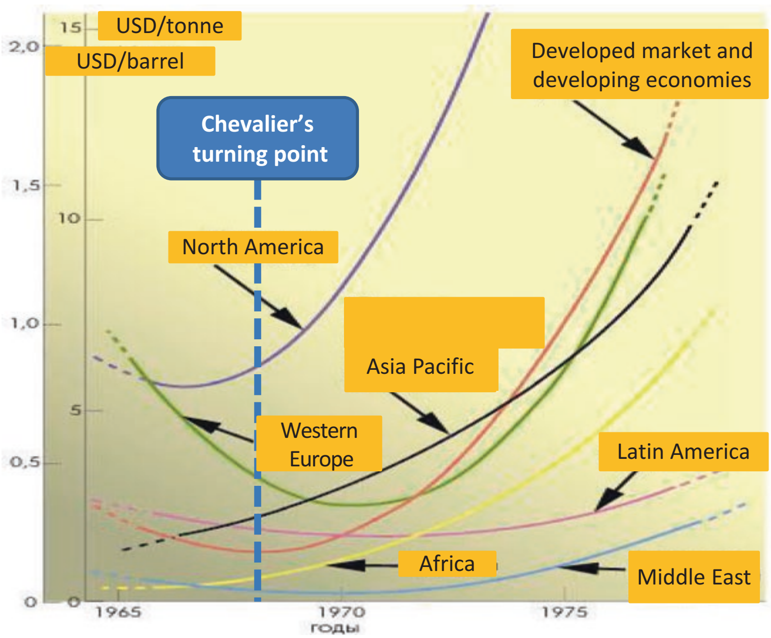
> In the fundament of our analysis we laid out the central hypothesis that in 1970–1971 the earlier trend of diminishing marginal production costs in petroleum industry has changed to their growth, at least in exploration of new fields and oil production… it is too early to prove this theory through the quantitative

analysis. In the given research we have tried to provide its general assessment only. (Chevalier, 1975: 21)

Subsequently, the present author was able to confirm J. M. Chevalier's assumption via calculations (Kurenkov and Konoplyanik, 1985) (Fig. 11.5), which prompted introducing the term Chevalier's Turning Point in relation to the laws of evolution of international energy markets.

In 1972 the first report to the Club of Rome 'The Limits to Growth' was published (Meadows et al., 1972), actually based on the theses by Hubbert and Hotelling. Strictly speaking, the popularisation of the Hubbert theory began precisely with that report to the Club of Rome. In response, the then Minister of Oil and Mineral Resources of Saudi Arabia, Sheikh Ahmed Zaki Yamani made his famous statement: "*The Stone Age had ended not because the stones ended, and the Age of Oil will end much earlier than the world runs out of oil*" (The Economist, 2003) having thus practically substantiated the inevitability of transitioning from the expectation of 'peak supply' to 'peak demand.'

The question then comes: Is that the phase transition we are seeing now?



Source: Kurenkov & Konoplyanik (1985)

Fig. 11.5 Adjusted dynamics of E&P costs for hydrocarbons internationally in the second half of the twentieth century (quantitative assessment of J.-M. Chevalier's central hypothesis)

2 World Energy: A Paradigm Shift?

Why does a paradigm shift occur, expressed as a transition of the public perception from the expectation of peak supply to peak demand? The ratio has changed in the expected dynamics of supply and demand, and of the factors acting on the side of each of these processes. Such factors include the accumulated effects of the response of the world economy to rising oil prices since the 1970s, the US shale revolution and its domino effects, the expected consequences of the Paris Climate Agreement (COP-21).

On the supply side, there was the combination of Hubbert's Curve and the Hotelling's Rule, which worked smoothly during the period after the Chevalier's Turning Point to first of all make extracting the resource rent a business objective via the effect of scale (to overcome the negative effects of the natural factor across that period), with the industry-wide STP targeting the same goal to a large extent. Meanwhile, demand followed the industrial development model, as a rule, with centralised energy supply remaining dominant (to realise the same scale effect). Population growth and the expansion of its access to commercial energy supply over time both worked in favour of an extensive growth of demand. This contributed to the expectation of a growth of demand outrunning the growth of supply, with the respective ratio of the peaks of the two curves shown in the left part of Fig. 11.6.

So what is happening now? The nature of STP has changed following a shift in the type of rent that it predominantly aims at extracting. Now it is not the natural resource rent (extracted mainly due to the effect of scale). Primarily it is the technological rent now due to the sharply increased development of shale resources (with totally different investment cycles compared to the development of traditional oil and gas) (Konoplyanik, 2015a) and of renewable energy sources (RES), both being aimed at the extraction of energy from significantly less concentrated sources (RES) and accumulations in the subsoil (shale) compared to traditional oil and gas or other fossil fuels. One example is offered by the US shale revolution, which is the main revolutionary transformer on the supply side at the moment (and not just of hydrocarbons only).

2.1 US Shale Revolution and Its Domino Effects (the Supply-Side Revolution)

The American shale revolution has been in preparation for a long time, kick-started 30-odd years after its 1974 conception by the Administration of the then US President Nixon with his Energy Independence Program. This was a

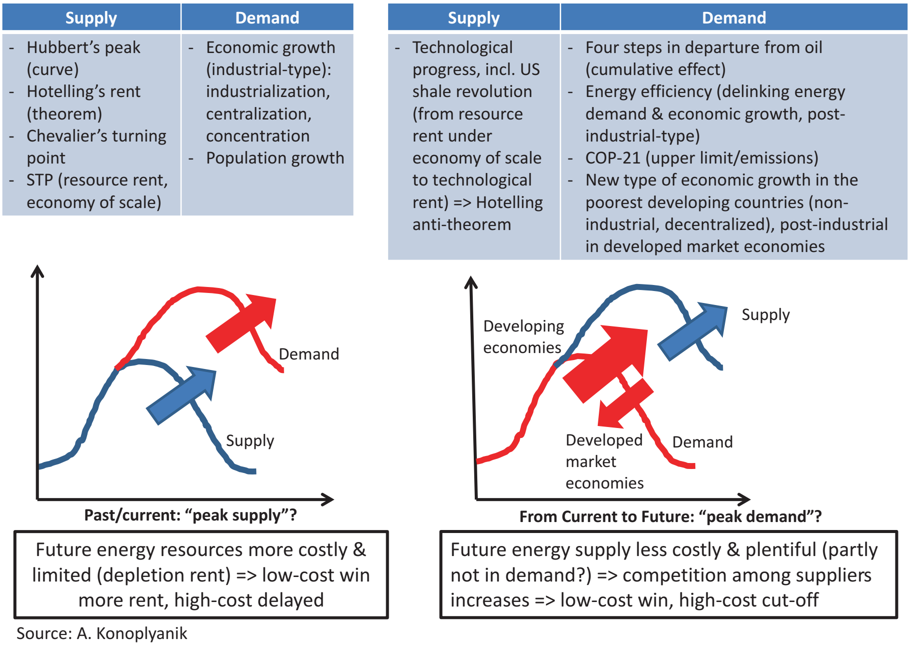


Fig. 11.6 World energy: the change of paradigm?

response to the oil embargo and rising oil prices by OPEC. In 1977, the President J. Carter Administration adopted the program, envisaging, among other things, large-scale government funding of fundamental R&D in 14 different areas (MIT, 2011), which promised, in principle, reducing national dependence on energy imports sometime in the future. One such area that proved successful was the design of commercial technologies to produce shale hydrocarbons (first dry gas, then fat/wet gas, and then oil) based on successfully combining three separate achievements of the revolutionary STP in a single technological complex: three-dimensional seismic modelling, horizontal and directional drilling and multiple reservoir hydro-fracturing (multiple fracking).

The American shale revolution took place in the second half of the 2000s, as a number of favourable circumstances combined, not least of which were the sharp rise in oil prices in the first decade of this century (Bushuev et al., 2013), the liberal nature of the US economy providing a quick response to new challenges (Konoplyanik, 2014a, 2016a) and the role of George Phidias Mitchell (1919–2013), generally recognised as the pioneer of the shale revolution.[10] Thus, the full innovation and investment cycle for the development

[10] According to The Economist, "*few business people have done as much to change the world as George Mitchell*" (The Economist, 2013). "*The rise* [in shale gas] *has been helped along by a variety of factors ... But*

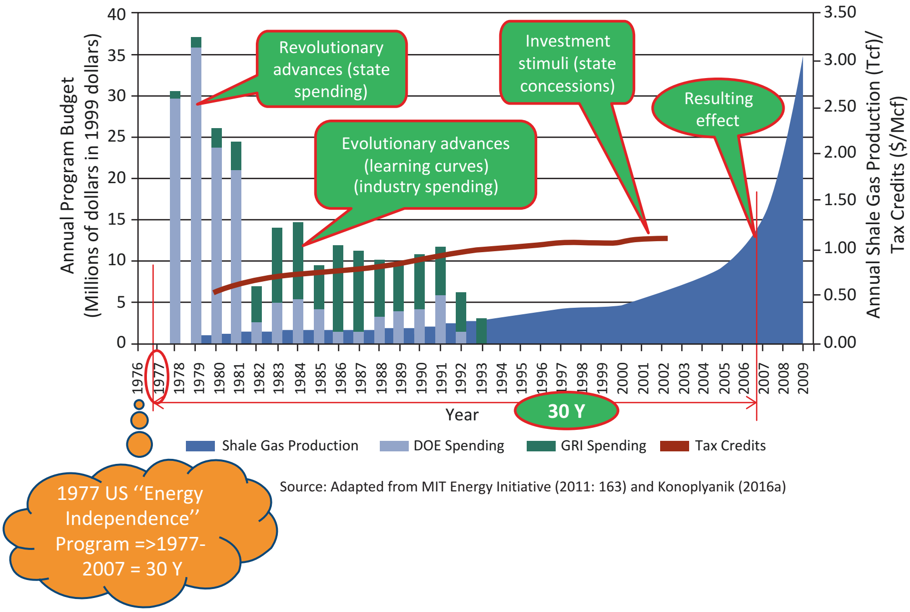


Fig. 11.7 Role of US state financing in stimulating the "US shale gas revolution"

of shale hydrocarbons, from the start of state funding of basic research to reaching a large-scale effect, with the resultant critical mass sufficient to launch systemic domino effects in turn, has taken about 30 years (Fig. 11.7). The US shale revolution caused a number of domino effects (Konoplyanik, 2014a, 2016a); if not turning it upside down, it definitely shook up the energy world very strongly and caused numerous multidirectional and—most importantly—irreversible changes in it.

What is fundamentally different between the production of traditional hydrocarbons and the production of shale hydrocarbons? In the first case, project operators make individual decisions on their development and financ-

the biggest difference was down to the efforts of one man: George Mitchell, … who saw the potential for improving a known technology, fracking, to get at the gas. Big oil and gas companies were interested in shale gas but could not make the breakthrough in fracking to get the gas to flow. Mr Mitchell spent ten years and $6m to crack the problem (surely the best-spent development money in the history of gas). Everyone, he said, told him he was just wasting his time and money" (The Economist, 2012). In this author's view, the role of George Mitchell in modern energy (in terms of the practical implementation of energy innovations which generated revolutionary and irreversible changes not only in the US, but in the global economy) is so great that he could have been short-listed for the annual 'Global Energy Prize', established by a group of Russian energy companies a few years ago (as an analogue to the Nobel Prize in energy to some extent). This author was a member of International Expert Committee of the Global Energy Prize in 2012–2015 and thus was not allowed to nominate candidates during this period. This is why, and since Mr Mitchell passed away in 2013 (the premium is not awarded posthumously), it was not possible to float this suggestion, voiced in 2014, because of procedural considerations (Konoplyanik, 2016a).

ing, while project (debt) financing for such projects is an art. In the case of shale hydrocarbons, it is a conveyor belt of drilling, both technological and financial: project financing is churned out and becomes a craft. As a result, two different types of hydrocarbons predetermine focusing on the extraction of two different types of rent (Konoplyanik, 2015a).

As a result, the potential zone of available supply expands dramatically due to an additional (advanced?) expansion of the area under the Hubbert's Curve while a huge cluster of such previously known energy resources,[11] which for long remained unconventional (i.e. unprofitable for large-scale development), move rapidly to take the place under the curve or become profitable to be produced and thus became new conventionals.

2.2 Global Multi-Facet Effects to Rising Oil Prices (the Demand-Side Evolution)

Several effects get superimposed in the demand zone. First, the accumulated effect of four consecutive steps of what can be called 'an escape from oil' of the world economy (Fig. 11.8) with its 'nesting doll effect' (when each succeeding step is superimposed on and complements the action of previous steps). These followed the oil crises and price hikes of the 1970s (see Fig. 11.8) (Konoplyanik, 2015a; Bushuev et al., 2013). First, this entailed a slowdown in the growth of energy consumption by industrialised countries, forming the initial prerequisites for reaching peak demand:

1. *'OPEC Oil Escape' in production*—Upstream competition (OPEC oil vs. non-OPEC oil): the development of previously unavailable or difficult-to-reach oil deposits outside of OPEC countries was made possible as these fields entered the area of profitability due to the technologies made available by the price hikes or with the use (commercialisation) of the achievements of revolutionary STP caused by such hikes. The international trade in oil and its infrastructure have diversified drastically, the range of supply sources increased, and 'oil versus oil' competition intensified. However, initially, prices leveled out instead of reducing the marginal (most expensive) sources which indicated the level for the establishment of official OPEC selling prices, and it was only from the beginning of the 1980s that the increasing excess of supply has started pressing the prices down until it collapsed in 1985 (see Fig. 11.8);

[11] Note that *Oil Economy*, the oldest Russian industry magazine, used to be named *Oil and Shale Economy* in the early 1920s.

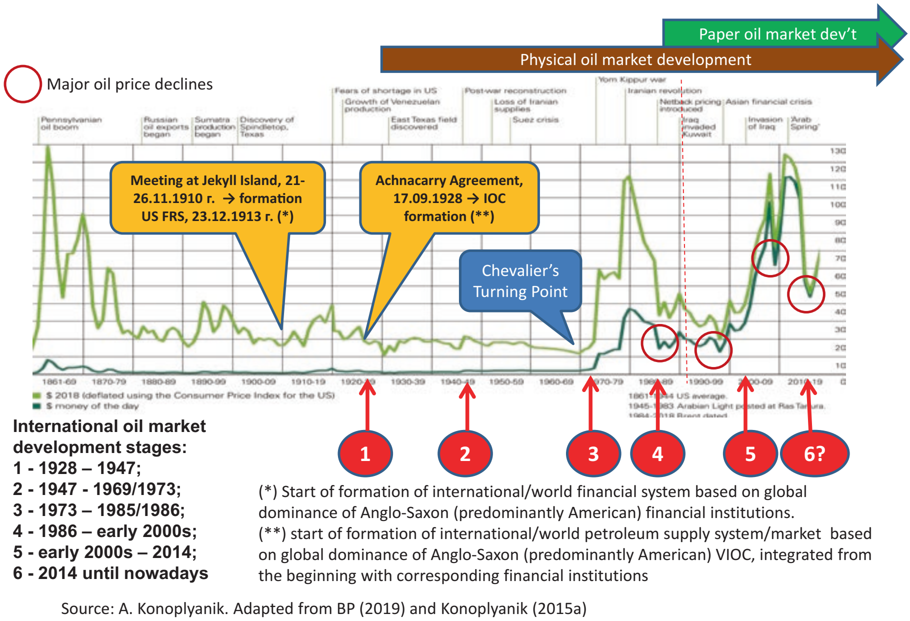


Fig. 11.8 Crude oil prices 1861–2018, US dollars per barrel, and world events (acc. to BP) and international oil market development stages and some related events (acc. to Konoplyanik)

2. *'Liquid Fuel Escape' in consumption*—Downstream competition ('oil vs. other energies'): The replacement of liquid fuel with alternative energy resources/energies where possible/available (e.g. gas, coal, nuclear, renewables, even non-commercial energies in less developed economies) as a result of both applying the achievements of revolutionary STP in non-oil energy consumption areas and (on top of) pure structural changes from oil to non-oil energies due to their price differences in cases of available technologically neutral appliances for specific energy in end-use. This has led to a slowdown (and a short-term cessation in the early 1980s) of the growth in demand for liquid fuels;
3. *'Energy Escape'* (substitution of energy resources with other productive factors), i.e. 'oil/other energies vs. other productive resources' competition; now costly energy resources were replaced by:

- *Labour (labour vs. energy)*—the transfer of energy intensive production capacities of energy consuming industries to developing countries and compensation thereby of expensive energy with cheap labour. This resulted in a structural increase of energy efficiency in the countries that imported energy, first and most in the developed market economies; and

- *Capital (capital vs. energy)*—the technological improvement of energy efficiency as a result of implementing the achievements of the revolutionary STP (along with measures to save energy, which may result from administrative measures). Increases in the technological efficiency of energy use in all segments of national and cross-border energy chains occurred primarily in the industrialised energy importing countries; subsequently, with a certain delay, these achievements spread across the entire world economy via the system of international economic relations, leading to a ubiquitous transition from an energy-wasteful type of social production (dominant until the early 1970s) to an increasingly energy-efficient one.

Second, changes are taking place in the public consciousness, resulting in voluntary (man-made) restrictions, collectively introduced, which restrain and slow down the growing demand. These changes stem primarily from the dominant perception envisaging the climate change and environmental degradation agenda relevance for sustainable economic development. The most striking example of such changes in the public consciousness is the Paris Climate Agreement (COP-21).

Third, a new type of post-industrial economic development appears to be forming in the most economically developed countries, on the one hand, and might be forming in the poorest ones, on the other hand. However, the task of providing further energy supply in developed nations and combating 'energy hunger'/'energy poverty' in the others (different in their initial causes but identical in the approaches pursued nonetheless) will not be pursued along the industrial development trajectory that the industrialised countries have taken with its predominantly centralised energy supply and based on economies of scale, where possible. Instead, it will occur by building up a predominantly post-industrial, decentralised, possibly individualised energy supply, following the wide range of possibilities that the current STP stage provides, though not necessarily 'digital, electrical, renewable' in all cases.

Moreover, the global energy industry is unlikely to ever become fully 'digital, electrical, renewable,' in contrast to the widely spread vision that is instigated today (or in the most recent past) in certain circles of EU countries. However, the presence of these three components becomes more and more significant, resulting in radical changes in the nature of the growth in energy demand and its further trajectory, including slowing down its subsequent growth. In its complexity, then, this provides a transition from the peak supply model to the peak demand model of international energy development.

The slowdown in energy demand growth, on the one hand, and the expansion of potential supply, on the other, lead to a buildup of potential supply surplus in the global energy industry. Due to the cumulative effect of these post-1970s developments, global technically recoverable oil resources exceed the forecasted volumes of accumulated (expected) oil demand by a factor of 3.7 over the period 2015–2035, and by a factor of two over the period 2015–2050; the respective excess figures for the proven recoverable reserves are 2.4 and 1.3 (Dale, 2017) (Fig. 11.9).

The development trends in R&D will lead to further expansion of the available reserve base of NRES and further diminishment of their E&P costs. The 'BP Technology Outlook' report (BP, 2015) illustrated this trend for the 2012–2050 period in regard to different types of liquid fuels (Fig. 11.10). Both increases in technically recoverable resources' volumes and diminishment of E&P costs will bring more additional reserves below the Hubbert's curve, thus serving to prolong the 'oil era' by diminishing perceived (by the alarmists and 'geologists' in the above-mentioned meaning of this term) reserve(s)/resource(s) limitations.

These figures confirm that humanity is not threatened by resource hunger; the problem arises, however, of the timely demand (payback) for those NRES

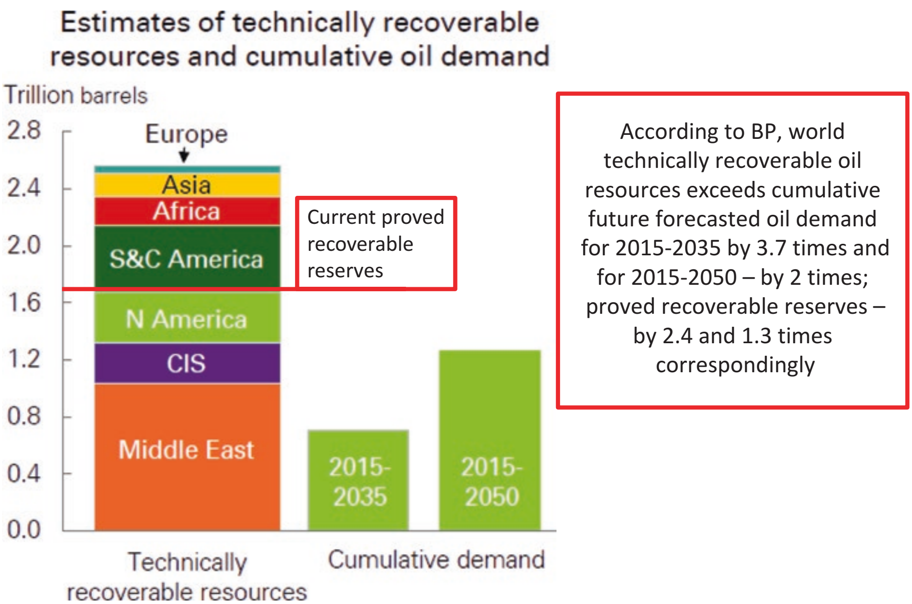


Fig. 11.9 There is no ground for 'peak supply' concerns already today. (Source: BP (2017) and Dale (2017))

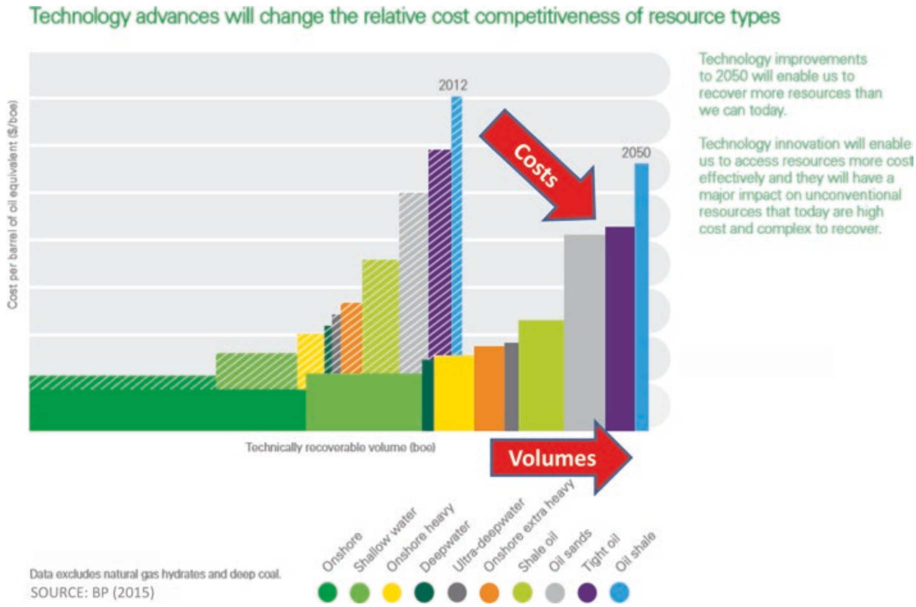


Fig. 11.10 The Role of STP in energy resource base development

categories which have substantial productive resources (intellectual, financial, and technological) already invested in identifying and preparing these NRES for development.

In addition to the cumulative response by the world economy to the oil and energy crises of the 1970s, on both the demand and supply sides, a man-made restriction on the demand side was recently added (Paris Climate Agreement), which radically accelerates the change of the energy paradigm and creates a system of new challenges for the energy industry both globally and in Russia.

2.3 COP-21 as the New Key Element of the New Paradigm of Energy Development (Demand-side Demand for a New Energy Revolution)

The Paris Climate Agreement is an agreement under the UN Framework Convention on Climate Change that regulates measures to reduce greenhouse gas (GHG) emissions by 2020. It was prepared to replace the Kyoto Protocol, and adopted by consensus during the Conference in Paris on December 12, 2015. The agreement was signed on April 22, 2016 and entered into force on November 4, 2016.

The Paris Climate Agreement actually sets new limits for the growth of the global energy industry by imposing restrictions on them 'from above', i.e. from the outside of the energy industries per se. According to the International Energy Agency (IEA),[12] the accumulated future CO_2 emissions due to the development (if would have occurred) of the world current proved recoverable reserves (CPRR) of non-renewable energy sources[13] (NRES) are three times higher than the upper limit of allowed emissions agreed under the COP-21 for the purpose of sustainable development (permissible warming of 2°C, maximum); the Intergovernmental Panel on Climate Change (IPCC) offers a similar assessment of an excess of 3–4 times (Konoplyanik, 2016b). It means that to keep global warming within the specified limits without large-scale implementation of CCS technologies, humanity will have to limit itself to using not more than 1/3 (according to IEA) or 1/3 to 1/4 (according to the IPCC) of global CPRR NRES. This means—only lesser (minor?) part of geological resources of fossil fuels that we do know of, that have been studied, technologies are available for their extraction (the technically recoverable resources) and which are economically viable for extraction, that is, prepared for extraction and are in essence 'production capacities' (current proven recoverable reserves) could have been permissible to utilise. Considerable funds have already been invested in preparing these resources for extraction. And these energy resources (as a category of productive resources) are the zone where the Russian economy of today retains its competitive advantages (see Fig. 11.1).

According to the IEA, 2/3 of all the above potential emissions are due to emissions from coal combustion, 22% belong to liquid fuel and only 15% to gas (IEA, 2012). Therefore, a natural question arises: if only 15% of all GHG emissions refer to gas, why is the main struggle for a cleaner environment in Europe directed today against the use of gas first of all? Is it not because the public opinion of energy-import-dependent Europe artificially associates the word 'gas' primarily with the phrase 'imported gas' and further on with 'Russian gas,' with corresponding negative connotations, especially after the Russia-Ukraine gas transit crises of January 2006 and January 2009 and in the current anti-Russian sanctions regime of post-2014?

The answer to that question is self-suggesting: all means are fair for certain countries which help remove a competitor from the struggle for a narrowing competitive niche for energy under the shift to peak demand paradigm of

[12] "*No more than one-third of proven reserves of fossil fuels can be consumed prior to 2050 if the world is to achieve the 2°C goal, unless carbon capture and storage (CCS) technology is widely deployed… Almost two-thirds of these carbon reserves are related to coal, 22% to oil and 15% to gas*" (IEA, 2012: 3).

[13] Within the technological chains leading from production/well-head to end-use of any separate type of NRES (coal, liquid fuel, gas) in each energy/non-energy area of their use.

international energy development. Therefore, a concept is actively promoted that Russia is supposedly an unreliable supplier (in particular, when the above-mentioned transit crises are referred to, one actual concept—risky transit route—is being apparently swung for another—unreliable supplier).[14] Based on this incorrect but well-presented and broadly disseminated in Western mass-media perception, another (not well justified and maybe that is the reason why it was not so broadly voiced compared to Russia-Ukraine transit disputes) policy endeavor was infiltrated into decision making circles in Europe: to substitute "*dirty imported foreign molecules* [by] *clean domestically-produced electrons*" (Konoplyanik and Borchardt, 2018).

If we take the IEA/IPCC figures as a basis, then the execution of COP-21 (Russia has not yet ratified it) will inevitably launch a chain of domino effects with (the risk of), inter alia, visible negative consequences for my country. Voluntary self-restrictions on the demand side, based on the climate agenda, will inevitably result in a sizeable amount of CPRRs staying out of economic demand globally. This means that a future potential oversupply is created, shaped artificially by the climate agenda. Moreover, whether it being an active present or a perceived future, but excessive supply always presses the prices down, reducing them. It will then not increase value/cost of NRES in the subsoil (as Hotelling claimed) but will decrease it due to potential lack of demand. One may say that this way an 'anti-Hotelling's theorem' or an 'anti-Hotelling's rule' is shaped/formulated (see Fig. 11.6).

As a result, incentives are created for the fastest extraction/use of these CPRRs, pressing their prices downward as well. These incentives will result from competition among producers, their struggle to try to be the first, to gain a competitive edge in a market shrinking on the demand side (against the expanding supply scale), so as not to be left unclaimed under the restrictions on demand imposed artificially by the Paris Agreement. This will accelerate the advent of the era of cheap oil, not due to any widespread reduction in the costs of its exploration and production though (e.g. a result of implementing STP achievements), but because in line with the above society will consciously be ready to pay an ever lower price for the energy supplied, knowing that this energy will become even cheaper tomorrow.

Adding the effect of implementing the Paris Agreement (COP-21) to the accumulated consequential reaction of the world economy to the hike of oil prices since the 1970s may change the paradigm of future development of the global energy industry radically!

[14] For the author's position on the nature of transit risks, where 'political' risks, i.e. the name of transit country is the last in the hierarchy of legal, regulatory, contractual, technical and only then (finally) political risks (see Konoplyanik, 2014b, 2018a, b).

3 The Shift of Paradigm: Risks and Challenges for Russia

Russia is facing serious macroeconomic challenges. The considered evolvement of events in the global economy (the coming paradigm shift in the development of the global energy industry) follows a direction forcing my country out from the sphere of its traditional competitive advantages in the global competition, which is the sphere of traditional NRES (and it may be further aggravated/accompanied by targeted attempts to achieve that goal).

The zone of the current competitive advantages of my country lies with its energy resources. Attempts to oust Russia from that zone mean that it may appear unready to compete on equal terms in the areas dominated by other productive resources, where other countries feature competitive advantages in other industries today (see Fig. 11.1). Speaking of technologies and innovations, my country is very strong of course and more than competitive in its defense industries, but it will not enable the country to solve all its domestic problems (compensate for its losses) if Russia turns out to be prematurely squeezed out of the zone of its traditional competitive advantages in the global economy. The loss of competitive niches in energy markets as a result of a deliberate (accelerated) premature reorientation of the global economy to a carbon-free energy industry will be catastrophic for Russia in case that it will happens before the transitional measures to diversify Russia's competitive presence in non-energy sectors of the global economy bring their spin-off.

3.1 COP-21: The Goal or the Means

The Paris Climate Agreement has become a part of the system of international law, albeit a 'soft' law. The question arises, what is the subject for discussing this topic? After all, if my country Russia have signed that agreement, it manifests an intention to ratify it, i.e. to put it into practice. Since this author used to work on preparing a number of international legal agreements for conclusion and worked for quite a long time in a representative international organisation (Energy Charter)[15] formed on the basis of a multilateral international legal agreement (with more than 50 member countries), he may claim some understanding of the logics of forming, structuring, negotiating, preparing for signing such a multilateral international agreement (including an 'insider's

[15] I have been involved in the Energy Charter process in different capacities since its very beginning, two weeks after the then Dutch Prime Minister Ruud Lubbers presented on the 25 June 1990 (on behalf of the EU) the 'Lubbers's plan' for development of the common European energy space.

view'), as well as its comprehension by participants before and after signing, during preparation for its ratification by the member states.

Until the agreement is signed, the players most interested in it, who are also the main drivers of its preparation process and main beneficiaries, as a rule, concentrate the attention of other participants in the negotiation process (as well as public opinion, both international and domestic) on the positive elements of the future agreement. Therefore, as the final phase of preparation of any agreement approaches, the task of signing it as soon as possible starts to dominate.[16] At that stage quick determination of mutually acceptable (or seemingly acceptable) outcomes fitting all the participating countries on outstanding issues (controversial and unclear) to quickly bring negotiations to the end starts dominating over the efficiency factor, which would be a meticulous clarification of legitimate concerns of the participants and search for the balanced compromise truly mutually acceptable and not-necessarily limited by the given time-frame. Therefore, at the final stage of preparation of multilateral agreements, the speed factor may become dominant over the efficiency factor.

When the agreement signed by the participating countries is submitted to the parliaments of these states for ratification, the process of rethinking the achieved result often begins; firstly, time (the 'speed factor') is not an issue anymore, and secondly, 'the collective member effect' which might be present during multilateral negotiations (roughly speaking, 'the crowd effect' which is 'to be like everyone else') is not there either.[17] On top of this, negotiators of the international agreements (at least related to economic issues) are usually representing executive branch within divisions of state powers, while ratification procedures involves representatives of the legislative branch. And it is not necessarily true that both branches within divisions of state powers have the same views on the issues in question. That is why at the ratification stage more attention starts to be paid not only and not so much to real and potential pluses, i.e. positives, but also to real and potential (and in case of conflict of the powers—to virtual) minuses, risks and uncertainties, i.e. negatives (perhaps not noticed previously, either by chance or deliberately). These can blur

[16] When politicians and/or civil servants see, in practical terms, that the potential end of negotiations is coming closer and closer, and it is possible to report soon this positive news—successful finalisation of the negotiations and signing the final agreement, they began to push negotiators to speed up with the aim to immediately report (and definitely within their term in office) successful results.

[17] Of course, one should not overlook the internal political factors arising at this stage, when the upcoming ratification of an international agreement, especially a multilateral one, on issues that the voters hear so much about (such as environmental protection and/or climate change); these may become an element (sometimes a bargaining chip) of the internal political struggle in a given country, especially on the eve of parliamentary or presidential elections.

the entire potential positive effect of such a multilateral agreement for a given individual sovereign country. This is exactly the stage (the moment of truth) that has come for Russia with respect to COP-21.

Therefore, it is important to draw the attention of the general public to risks and uncertainties connected with the possible consequences of COP-21 for Russia, which, in my opinion, remain underestimated or overlooked, at least within the scope of the public discussion, judging by publications in the media.

The players most interested in the preparation of COP-21 (and its main potential beneficiaries) are, first of all, the countries that account for the bulk of atmospheric emissions. In that area Russia is not among the leaders as it is not one of the main polluters. In 2015, the US accounted for 17% of global CO_2 emissions, the rest of the OECD countries accounted for 21%, China accounted for 27%, and other non-OECD countries accounted for 31%; Russia's share then was only 5% (BP, 2019).

In this situation a critical re-thinking of what was signed in Paris is therefore important for Russia. What does COP-21 mean for Russia with its consequences? It is necessary to use the ratification procedure (the period of time allotted for it, which according to some authorities may be the period up to 2019–2020, i.e. to be finished soon, maybe even before this book is published) for critical re-thinking of all the possible outcomes, focusing primarily on the possible negative consequences of COP-21 for Russia, and how these effects fit into the system of Russia's national interests.

The goal of the Paris Agreement (Article 2.1(a)) is to "*enhance the implementation*" of the UNFCCC, in particular by "*holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels*" (UNFCCC, 2015). This is not an obligation of the 'hard law' category ('the Parties shall') that would legally oblige the parties to ensure the result. Rather, this is an obligation of the 'soft law' category ('the Parties shall endeavor'), since COP-21 does not have enforcement tools to ensure that this goal is achieved. However, it goes to say that the participating countries need to make efforts to limit the rise in temperature to 1.5°C (according to COP-24 as of December 2018 in Katowice). This means they are invited independently to undertake the more radical, tougher and more ambitious task of escaping from traditional, mostly fossil-fuels-based, energy systems towards a new low-carbon system built primarily on a wider application of RES[18] which

[18] Radicals speak of the dominant use of RES, extremists speak of a full-scale replacement of fossil fuels by RES (author's use of terminology).

reorients energy development from the primary extraction of natural resource (mineral) rent to extraction of technological rent.

The parties to the Paris Agreement "*aim to reach global peaking of greenhouse gas emissions as soon as possible*" (Article 4.1). "*Each Party shall communicate a nationally determined contribution every five years*" (Article 4.9). "*Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition*" (Article 4.3).

As mentioned above, the 'soft law' system does not provide for any enforcement mechanism, both in terms of declaring national goals and in ensuring that they are mandatory. The effect of collective behaviour '*those who are not with us are against us*' begins to work here. That is, if you have signed this agreement, then let us act together (the 'crowd effect') so as not to be an outcast (not opposed to the general behavioural trend). At worst, one should '*not lose face*'. Thus, a certain collective pressure is exerted on all participants, so that they all voluntarily both sign this agreement and start implementing it (remember there is no formal enforcement), frequenting more and more ambitious tasks even more often than every 5 years.

In view of the above, the question arises: are the colleagues/partners/rivals in global competition forcing Russia to neglect, in a voluntary, fast and very costly manner, its current global competitive advantages (which mostly reside in the area of natural NRES) and start competing in the area of other productive factors, where Russia and other countries have no such competitive advantage today, neither in capital nor in labour? It is possible that, in time, having passed through a transition period (provided a relevant state economic policy would be shaped and implemented), Russia might be enabled to compete in the labour and capital markets on a global scale. But to enter that zone of future competitive advantages, Russia would need to pass smoothly through such a transition period first. And this takes time, money and respective government policy.

Therefore, if today (prematurely) some countries are trying to force other countries to voluntarily leave the zone of its current competitive advantages and reach the zone where Russia might, with the appropriate domestic economic policies in energy and investments, gain such possible future competitive advantages over time, should these other countries not consider COP-21 (not in full, of course, but at least in part) as another tool of global competition policy used to weaken or remove competitors? In this case the competitor is the Russian Federation.

Taking into account the above, both risks and new opportunities should be assessed stemming from the ratification of the Paris Agreement by

Russia in both its domestic and foreign markets, in its energy industry and regarding global competition outside the energy sector. Let us start with the risks.

3.2 Risks and Challenges for Russia in the Oil Sector

Today, there are three major players in the global physical oil market: OPEC countries led by Saudi Arabia; the US; and Russia. They are the main competitors in the oil sector too. But while Russia and OPEC are the countries that produce traditional oil, the production of liquid fuels in the US today is mainly that of shale oil; most importantly, its investment cycle is completely different from that of traditional oil (Konoplyanik, 2015a, 2016a). The author's vision of the comparative location of these producers on the global oil supply curve is presented in Fig. 11.11.

The logical question is: 'Where (on which part of the supply curve) will they reside tomorrow?' Will they keep their competitive niche in the low-left part of cost curve with least costly CPRR still in demand by end users (below

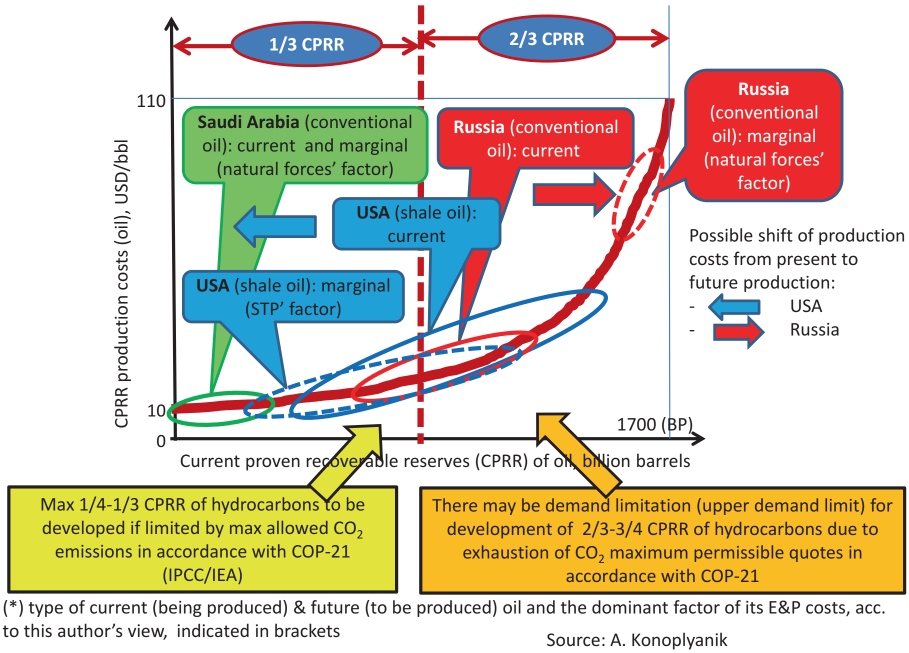


Fig. 11.11 US shale oil and COP-21 influence on global oil supply curve: consequences for Russia

the ceiling provided by GHG emission restrictions), or will they proceed to the upper-right part of cost curve with the costliest and thus potentially unclaimed volumes of CPRR?

Saudi Arabia was, is and will remain in the lower zone of the spectrum (see Fig. 11.11). The Kingdom will remain in the lower left zone, while it keeps producing conventional oil as this is where its current and future marginal costs land, i.e. the costs of those fields that will go to compensate for the disposal of existing facilities, to compensate for decline in production by the existing deposits. The costs of oil production in Saudi Arabia will remain so due to the dominant influence of the natural factor. Meanwhile, production costs of the US shale and Russian traditional oil will go through the oppositely directed shifts along the global supply curve, with time.

In terms of production costs, the US and Russia today are in the middle of the supply curve (in the middle of the CPRR[19] resource spectrum). The difference is that the US is producing shale oil, while Russia produces the traditional one. These two generate fundamentally different investment mechanisms of oil production, since the life-cycle of traditional oil wells is 15–20 years, and that of shale oil wells is 2–3 years with a very sharp drop in production (by 50–60% during the first year and by 80–90% in two years). That is a big minus for producers of shale hydrocarbons, since they must keep drilling new wells constantly to compensate for the rapid fall in production rates (to compensate for the loss of production capacity). It builds up their financial indebtedness very fast: the financing of investments of shale producers goes via debt financing, and that deteriorates the bankability (financial quality as debtors) of these producers as borrowers against the declining oil and gas prices. Credit is getting more expensive for them, and the debt spiral unwinds while debt quality deteriorates.

However, continued access to finance and the necessity to constantly renew production facilities (to intensively drill new wells) enables shale companies to reduce production costs within the real-time frame. According to ERC IMEMO RAS experts, this situation does not threaten the industry with financial collapse. In their opinion, a crisis similar to the 2007 crisis in the US real estate market will not take place "*because only individual enterprises will go bankrupt, but there is no threat of bankruptcy for the industry as a whole*" (Zhukov and Zolina, 2016).

[19] BP estimates global CPRR oil at 1.7 trillion barrels. Since these estimates were made for the price margin existing at the moment, at the level of US$110/bbl over the entire first half of the current decade, the present author placed a hypothetical supply curve within the rectangle of respective coordinates to indicate the competitive advantages of the main competing states in this market.

It is argued here that the cost of shale oil production in the US will shift to the left and down the supply curve, since shale oil production is characterised by a fundamentally different innovation and investment cycle compared to traditional oil production. It is much shorter (2–3 years vs. 15–20 years for traditional oil) for shale oil, featuring a much steeper learning curve; within the framework of the liberal American macroeconomic model, as applied to the oil and gas industry, it keeps generating innovations continuously, that work to reduce costs within the framework of that learning curve almost in real time. In fact, this innovative production cycle is akin to the production cycle in manufacturing industries, allowing one to operate in a kind of a 'drilling conveyor' mode (Konoplyanik, 2015a, 2016a).

In Russia, it is the traditional oil deposits that bridge the balance of oil production. Such development is characterised by a long, therefore inertial innovation-investment cycle. Oil fields are located in more and more complex natural conditions, far from any inhabited well-developed areas featuring sufficient infrastructure. The macroeconomic costs of developing new territories, forming basic infrastructure and so on, will be imposed on the project costs. This will lead to increased oil production costs due to the natural factor especially if the current state tax policy is maintained, determined, as it were, not by any long-term 'philosophy of development,' but the short-term, momentary pure-fiscal 'philosophy of the tax collector' (Konoplyanik, 2015b, c). Therefore, by moving right-and-up along the supply curve Russia may be forced into the zone of those two-thirds of the unclaimed resource potential of CPRR. It is necessary to respond to these risks. First of all, what is needed is the change in (improvement of) the investment climate in Russian oil and gas and related industries (Konoplyanik, 2015d).

Hence, one may conclude: when we speak about the marginal fields for which commissioning is to compensate for the decline in production at existing fields, US shale production will move its costs left-and-down the supply curve, and in Russia, with its traditional oil, production costs will move right-and-upwards along that curve to the zone of deteriorating natural conditions, provided the current investment climate is maintained. Since, as IPCC/IEA experts felt, only 1/3–1/4 of the world's CPRRs will stay in demand within the scope of shrinking demand in the long term (under the man-made 'peak demand' paradigm), can it be that the new Russian oil will fall into the range of unclaimed energy resources? Today, these possible risks and challenges require active discussion and corresponding action with the aim to effectively monetise Russian NRES under new 'peak demand' paradigm.

3.3 Risks and Challenges for Russia: The Investment Climate

New challenges facing Russia are connected with the state of its investment climate, including in energy. Russia needs an innovative way of developing its natural resources. The active supporters and propagandists of that approach are, for example, RAS Academicians A.N. Dmitrievsky and A.E. Kontorovich voting for a 'resource-innovative' development path for Russia. What is needed is not an 'escape from oil,' but a three-directional intensification of measures to preserve and strengthen Russia's competitive advantages in the energy sector by monetising its vast energy resources within optimal (from a national interests view and within 'cost-benefit' macroeconomic analysis) transition to new innovative technological tenor within the overall global trend to a low-carbon economy based on climate considerations. This should include 'new' energy sector adjustment/reincarnation to new realities, i.e. taking into account the new paradigm of international energy development.

The first direction of adjustment consists in implementing achievements of the revolutionary STP in mineral-resource and related industries that produce equipment for energy industries (engineering, production of goods and services for the energy sector), i.e. production of competitive equipment for the energy economy in its old and new branches. This will lead to lower costs (a radical drop thereof in the case of revolutionary STP to overcompensate for the negative impact of the natural factor),[20] to a higher ROI, but most importantly—diminish demand for investments in the energy economy against the retained volumes of primary energy involved in the economic turnover. That, in turn, will make it possible to more actively convert unconventional energy resources into conventional ones, to enlarge the area under the Hubbert's Curve to prolong the hydrocarbon era which for Russia could (dependent of state economic/investment policy) prolong the time and expand the sphere of its current international competitiveness.

This, of course, should be merged with the demand for low-carbon development and (radical—as presented by 'climate alarmists') decline in GHG emissions in a mutually acceptable manner, firstly for Russia and the EU as parts of the single 'Broader Energy Europe' area, which unites the countries of the whole geographical Europe, Northern Africa, part of Russia's Asia (Western Siberia), Central Asian states (soon, probably, Eastern Mediterranean

[20] For example, in the 1980s/1990s the costs of offshore deep-sea oil production off board semi-submersibles of new types (free of stationary bases) on the Brazilian shelf with water depths below 1 km appeared to be lower than those of the North Sea stationary platforms (either pile or gravitational) at water depths of less than 200 metres.

and, maybe, even Middle East states) with common cross-border immobile capital-intensive long-distance energy infrastructure. This de facto joint (in a technical and geographical meaning) infrastructure is an integral part and a common denominator for finding joint solutions for the low-carbon energy agenda by balancing both more and/or less radical national views on decarbonisation, resulting from a higher and/or lower placement of the climate agenda in the system of national priorities compared, for instance, with the task of national economic growth, increases in living standards (per capita earnings) and quality of life (in which case climate issues might be only part of the issue).

One of the potential competitive opportunities for the traditional energy industry could consist, for example, in extending the 'primary' energy technological cycle of NRES beyond its end-use stage by creating effective 'secondary' energy technological cycle via efficient use of CO_2 emitted in the primary energy cycle. This means to effectively (in an economically justified way) to absorb and monetise CO_2 emissions: currently an unwelcome output of the primary cycle, it should be used as a welcome and effective input into the secondary cycle. That, however, will only become possible, under the current state of technological development in regard to CO_2 utilisation, when CCS technologies progress from being the end of the current energy technological cycle (next to today's final stage in the energy cycle where end-use energy is split into useful work and losses and emissions, including CO_2 emissions) to becoming an integral starting element of the secondary cycle (see also Chap. 2 for a detailed discussion of carbon storage and mitigation technologies). CCS may be the initial part of the new technological energy cycle, for example, a hydrogen one where CO_2 will no longer be any loss/damage/pollutant, but a material resource used to produce clean energy such as hydrogen based on new breakthrough technologies that utilise CO_2 via, e.g. its methanation (i.e. conversion into environmentally pure methane). This is the way that dominant thinking on the EU side has been taking place triggered by Norway and UK which see new business opportunities such as using depleted North Sea fields for CCS purposes.

This means that CCS should be translated as 'carbon capture and storage'. In this case, the storing of CO_2 could be considered as a part/start of the new (secondary) investment cycle—as a part of its utilisation cycle—and its economics can be calculated. So far, this is not the case. As of today in the majority of cases CCS shall be translated as 'carbon capture and sequestration' (Konoplyanik, 2019a, b). This means that the costs of CCS in economic terms are not an investment (since it cannot be repaid, paid-back, returned by CO_2 productive use) but a pure cost, i.e. CCS costs are a burden.

However, a more promising route is to develop technological solutions for the shift to a low-carbon energy economy through a hydrogen path by developing technologies of hydrogen production from methane without access of oxygen and thus without CO_2 emissions (this will be addressed below).

Russia needs a longer transition period from the oil era to a low-carbon economy, instead of an abrupt transition that leaves no time for adaptation; Russia needs no leap from the oil era to the low carbon era. Such transition measures would aim at maintaining a competitive energy supply (means, with diminishing production costs non-dependent worsening natural conditions for energy production) as a result of relatively lower investment costs generated by (first of all, revolutionary) STP achievements in the country, with direct participation of the state and with its full support. A respective example is offered by the history of the US shale revolution and the role of the state in financing R&D that launched that new 'industrial' revolution (Konoplyanik, 2016a; MIT, 2011).

The second direction is that of increasing energy efficiency, i.e. cutting back of specific energy intensities and, possibly, in result, of the absolute needs for primary energy supplies. Some developed market economies have already fully decoupled economic growth and energy consumption contrary to a direct linear correlation, almost equal to 100%, at the beginning of their 'the long and winding road'[21] from energy-wasteful to energy-efficient economies. This path leads to a relative (but may also result in absolute) decrease in demand for gross investment in the energy economy. That, in turn, will offer an opportunity to take a pause in developing the most expensive marginal resources or a temporary break in their development.[22] This might possibly reduce the financial and investment burden on the economy by the energy economy while exerting the same useful work, with the same amount of energy supplied. The result may consist in both increasing or maintaining the volume of primary energy and also sustaining the volume of end-use energy thanks to lower costs of its production. Meanwhile, reducing the financial and investment burden on the economy by the energy sector with the amount of useful work unchanged suggests a possibility to concentrate the released

[21] Citation from The Beatles' 'The Long and Winding Road' song from their 1970 album 'Let It Be'.

[22] In particular, one may consider present-day practical development of the Arctic shelf employing existing technologies, i.e. those achievements of evolutionary STP, which prevent Russia from reaching further than the shallow-water arctic coasts, so far, at certain environmental risks (Konoplyanik et al., 2015). Such a pause would allow one to concentrate on the relevant achievements of the revolutionary STP. It should be understood though (consider the example of the US shale revolution) that the innovation and investment cycle for breakthrough technologies, such as robotised underwater and subglacial technologies, may be quite long in duration: the US shale gas revolution took about 30 years (Konoplyanik, 2016a).

resources on R&D for revolutionary STP in the new energy spheres and other industries.

The third direction is that of increasing the efficiency of using financial revenues from the energy sector to reduce the tax burden on it in its role of a state's budgetary donor. The current Russian tax system in the subsoil (based on mineral resource production tax plus export duty) is not optimal, to put it mildly (Konoplyanik, 2015b, c).[23] Added to that are the issues of rational and efficient use of budgetary funds: consider, for example, the corruption component or 'corruption tax' of the Russian economy, which may reach at least 20%, as was declared at the highest state level (Konoplyanik, 2015d).

The foregoing are those possible thrusts aimed to sustain and extend the transition period from the hydrocarbon era to another (low carbon) energy era, i.e. hold Russia in the sphere of its competitive advantages in international markets against the coming change in the development paradigm in international energy. The task is to ensure holding Russia in the sphere of its competitive advantages within the framework of the global competition at the innovative technological level of the new tenor of technology based on the achievements of the revolutionary STP.

3.4 Risks and Challenges for Russia in the Gas Sector

As noted above, IEA calculations show that 2/3rd of the accumulated future potential CO_2 emissions due to the combustion of CPRR NRES account for coal, 22% for fuel oil and 15% for gas (IEA, 2012). The question arises: if 2/3 of the emissions are coal-related, and only 15% are with gas, then why was Russian gas the main target of the struggle, supposedly within the climate agenda? It is argued here that the answer must be sought in the zone of the expected US LNG competition against Russian pipeline gas in Europe within the narrowing competitive zone for natural gas. As certain European politicians claim, natural gas is just one of the types of fossil fuel and thus is as bad as other fossil fuels from a GHG emissions view, even if it is the least polluting fossil fuel from an environmental point of view. If so, then one would seek to remove a competitor at all costs. Hence, the struggle against the Russian pipe-

[23] This author has long been a steady opponent to the current fiscal-oriented, non-differentiated tax system, which is not project-based but rather corporate-based. This type of Russian subsoil taxation has been developed since the early 1990 under the dominant pressure of the Russian Ministry of Finance. This author has developed (as a head of drafters) an alternative tax regime for Russia's subsoil use based on production-sharing agreement (PSA) experience. This regime was passed into law, but due to later developments only three projects have been developed today in Russia under a PSA regime: Sakhalin 1 and 2 and Khariaga (Konoplyanik, 2013d).

line gas as one of the fossil fuels has been converted (Gazprom's gas, Putin's gas) into the struggle in favour of US LNG. These are (some of) the (immediate) risks of decarbonisation (the climate agenda) for Russian gas in Europe, the main former, current and future export market for the Russian gas within what this author has termed the 'Broader Energy Europe' vision.

Actually, decarbonisation (the climate agenda and its accelerated implementation in the EU) opens up new (potential) opportunities for Russian gas on the European market. Let us consider these multidirectional consequences of decarbonisation (the European climate agenda) for Russian gas in more detail.

3.4.1 Playing Against Russia/Gazprom (by Changing the Rules and/or Abandoning Them) in a Shrinking Competitive Niche for Gas in Europe: New Risks of Non-competitive Behaviour?

Many experts and organisations[24] have shown that US LNG can be competitive with Russian gas in Europe under the current conditions if only current cash costs are taken into account (SRMC/OPEX) with disregard to anything else, i.e. not considering the full costs (LRMC/CAPEX+OPEX). All investment decisions concerning the US LNG projects were made during a period of high world oil prices: US$100–100/bbl range in the first half of the 2010s before collapsing in mid-2014. All US LNG projects were designed to gain the Asian premium in the LNG market as the first/preferential option: after the Fukushima nuclear power plant accident in Japan in 2011, prices for LNG in the Asia-Pacific (in North-East Asia, at the key Japan-Korea market) were steadily higher than those in other regions and even more so than those in the US domestic gas market.

PP-indexation built into the Russian LTGEC kept the then prices for Russian gas in Europe high, which, given the oversupply of gas on the EU market, could have made it uncompetitive against US LNG, if the latter was delivered to Europe, should the oil prices remain high and Russian PP-indexation prolongs when US LNG export begins.

Until the beginning of 2016 (before the start of US LNG exports), the US remained an energy island. The growth of shale gas production led to a drop in its prices in the US domestic market. The drilling for shale gas continued (to keep the license areas) mainly within the scope of debt financing. This

[24] Cf. Konoplyanik (2016b, c, 2017b).

means that that industry is significantly over-credited today in anticipation of the possibility to start exporting the US LNG, enter foreign markets with their higher prices and gain the opportunity to reduce (pay off in the long run) the accumulated debt of the US shale gas companies. These companies represent the largest segment in the US 'junk bond' market today, i.e. financial instruments with speculative ratings (below 'BB-'), while bond placements are the main instrument of project/debt financing (Konoplyanik, 2015a, 2016a).

However, in mid-2014, world oil prices dropped by half, which altered dramatically (worsened) the competitive prospects of US LNG in export markets against gas with oil peg (both against the LNG in Asia-Pacific and pipeline, i.e. Russian, gas in Europe) (Konoplyanik and Sung, 2016). This author is not a supporter of the views claiming that the global oil prices will rise and drag gas prices along with them, thereby increasing the competitiveness of US LNG in Europe. The current price situation in the European market, in which the sale of US LNG in Europe covers only its current cash costs, will persist for quite a long time.

Under these conditions, the possible goal of fighting against Russian gas in the EU is purely pragmatic and utilitarian: try to remove a competitor of the US LNG away from the shrinking competitive niche for gas in the EU, in which the winner is the one with a lower cut-off price in the target market. When the EU is the target gas market and both US LNG and Russian pipeline gas are to balance it, the latter has the lower level of cut-off price at the consumer level (Konoplyanik, 2016b, c, 2017b). In part, this shrinking competitive niche for NRES is the result of the agenda that the Paris Climate Agreement sets (top-down cap on demand through limitations of GHG emissions).

If so, when it is impossible to remove a competitor in an honest struggle, relying on market forces, how else can one remove that competitor? By creating administrative and/or other barriers for the competitor to access the market, worsening artificially its (in this case Russian pipeline gas) competitiveness in Europe. Another strategy is to create an unfavorable image of the competitor: as if it is not too reliable a source of supply on offer to European customers, on top of this, a product not too clean environmentally while environmental issues are of top priority and sensitivity in the EU. It is argued here that this anti-Russian propaganda (both in gas and beyond gas) is being done (including by the joint efforts of the US and the EU) in favour of US LNG in Europe since it has been repeatedly shown that it is less competitive compared to Russian pipeline gas in Europe (Konoplyanik, 2018c, d, e, 2019c, d, e, f).

All the pieces (just a few examples are provided below) of the puzzle fall together tightly forming a single group according to their origin—with the intention to diminish the role of Russian gas in the EU market (in favour of US LNG, according to this author's understanding) since it is Russian gas that seems to win the economic competition under the new 'peak demand' paradigm which sharpens the competitive niche for gas in Europe under its proclaimed movement to a low-carbon future:

1. Recent Western studies tried to demonstrate that Russian gas is allegedly the 'dirtiest' compared with Algerian, Qatari, and Norwegian gas. The fallacy of these conclusions was substantiated within the framework of Work Stream 2 'Internal markets' of the Russia-EU Gas Advisory Council (WS2 GAC) (Müller-Syring et al., 2017; Kuhn and Romanov, 2017),[25] but this has already entered European public consciousness and taken on a life of its own;
2. The constantly emerging obstructions aimed to stop development of the pipelines destined for Russian gas and meant to either avoid transit (under Northern routes—Nordstream 2 pipeline, since Nordstream 1 is already built) or to diminish the number of transit states (under Southern routes—former South, now Turkish Stream pipeline) on the route to the EU. However, their construction is aimed to improve reliability of Russian gas supplies to the EU[26] (to reduce existing transit risks, cf. Konoplyanik, 2014b, 2018a, b, f, g, h) after the transit contract with the Ukraine expires in 2019 while the EU long-term supply contracts remain valid after 2019 and continue through to mid-2030s. Since respective gas delivery contractual points are placed far in the depths of Europe, and it is responsibility of the supplier (exporter) to deliver its gas to delivery points, the bypass pipelines (now a part of the newly developed circle-radial supply system) can reach there. Thus, 2019 is a relevant time for reassessment and reprioritisation of export flows to the EU (an advanced reorganisation of the transportation capacity export system from a linear (radial) system established during the USSR within the COMECON political geography[27] to a circle-radial system of Russian gas supplies to the EU[28] which is more adequate

[25] These and other materials of WS2 GAC can be found at http://www.fief.ru/GAC.htm.

[26] As the contractual responsibility for proper delivery of Russian gas, in terms of time, volume, quality, etc. to delivery points in the EU falls on the supplier.

[27] Justified then under the USSR GOSPLAN philosophy 'one market—one pipe' when all Soviet gas export deliveries to Western Europe were under the control of corresponding Soviet authorities from the well-head deep in the USSR to the delivery points at the EU-COMECON border.

[28] Which now reflects the diversification principle of improving reliability of supplies and energy security where 'diversification of routes' favours both the importing and exporting states and provides them free choice to select (if geographically and politically possible) the preferential routes uniting them either directly (without transit) or through this or that transit state(s). Since supply responsibility lies with the

to current political geography and regulatory systems in gas in Europe (Konoplyanik, 2014b, 2018a, b, f, g, h). When the construction of new pipelines is over, the structure of Russian gas flows to the EU will be changed. Key gas flows will go through the new modern pipelines ('circle' part of the 'radial-circle' transportation system) with full economic utilisation of its capacity (helping to diminish transportation tariffs and thus creating preconditions to win supply competition at the oversupplied EU market if/when the gas (commodity) prices go further down). But the radial part of the new 'radial-circle' system will also stay in demand (if adequately modernised and provided competitive tariffs): these historical linear corridors (as an integral element of the new 'radial-circle' system) will provide flexibility for the EU and will help Russia to balance flexible gas demand at the EU market with least costs and thus be able compete with more costly US LNG. In this scenario, the Ukrainian GTS will play the role of the swing/balancing route for the EU gas market (but only if it is adequately modernised) similar to the role that Saudi Arabia has been playing in the physical oil market. This new role for the Ukrainian GTS will be different but not less important within the 'Broader Energy Europe' than its historical past role as a key transit corridor for Soviet/Russian gas to the EU;

3. Another piece of puzzle has lasted for 7-year meddling by the EU with the issue of full utilisation of the OPAL gas pipeline capacity (an onshore extension of the Baltic sea route of Russian gas supplies to the EU bypassing the Ukraine) which was for long allowed to be used only by 50% based on an arguable interpretation of the provisions of the Third Energy package. Nordstream 1, OPAL and Gazelle pipelines are just the integral parts of the single pipeline system aimed to deliver Russian gas by the non-transit route to the same delivery points in the EU where supplies have been historically delivered to through the Ukrainian transit corridor. Prohibition to utilise full OPAL capacity means worsening economics of the whole pipeline system, thus increasing transportation costs and diminishing supply margins for Russian gas through this route. This worsened (through artificial administrative barriers) the competitiveness of Russian gas in the EU delivered through this route;

exporter, it is their legal right (which is in line with the EU legislation of the unbundled internal EU gas market) and preference/priority to select the least risky route to the destined market. A transit state has no legal rights to demand that exporter shall define for transit the territory of this particular transit state—it can only persuade the exporter by providing them with the least risk and best economic conditions for transit compared to alternative routes which the exporter will assess within their own system of arguments regarding transit risks (Konoplyanik, 2014b, 2018a, b, f, g, h).

4. Another mechanism of creating an unfavorable image is the incessantly repeated claim that Russian gas is an unreliable source of supply to the EU. That is a shameless substitution of notions: instead of talking about Russia as an unreliable source of supply, one should talk about the unreliable/risky transit route for Russian gas supplies to the EU across the territory of the Ukraine;
5. The creation of artificial administrative and economic barriers for Russian gas in the EU under the umbrella of improving efficiency of the regulatory system for the EU internal gas market. One of the most recent examples of this kind is the Commission's Quo Vadis project (2016–2017) (Konoplyanik, 2017b, c, d, e, f, g, 2018i, j). This has provided a few scenarios of (rather radical, from my view) changes in the regulatory system in the EU in favour of US LNG and against Russian pipeline gas which lead (if implemented) to the diminishing welfare of EU citizens. In the end, following intensive debate, the European Commission has called it 'just an intellectual exercise'. However, it is argued here that concerns remain that provisions of this project may be adopted by the new Commission as its roadmap for regulatory actions; and
6. Direct promotion of US LNG against Russian pipeline gas in the EU (Konoplyanik, 2018c, d, e, k, 2019c, d, e, f).

3.4.2 Additional Opportunities (New Challenges) for Russia/Gazprom in the EU as a Result of Decarbonisation of the European Gas Industry?

Meanwhile, decarbonisation and the paradigm shift create new prospective challenges for Russian gas in Europe which might be mutually beneficial for both parties.

Historically, primary energy supplies internationally consisted of chemical (NRES) and electrical (RES) energy. Part of the primary chemical energy of NRES was converted into electrical with CO_2 emissions and both were used in end-use. After the climate agenda moved to the top of EU priorities, a new vision appeared (called here the 'First EU energy vision') to move the EU to a RES-only energy market, i.e. to make it 'digital, electrical, renewable'. This would have left no long-term challenges for gas (non-dependent its origin) in the EU except to consider gas as just a 'transition fuel' for some limited period leading to the bright RES-based EU future (Fig. 11.12).

But since early 2018 this unrealistic concept was adapted to the more realistic 'Second EU energy vision', which has created new prospective challenges for Russian gas in Europe.

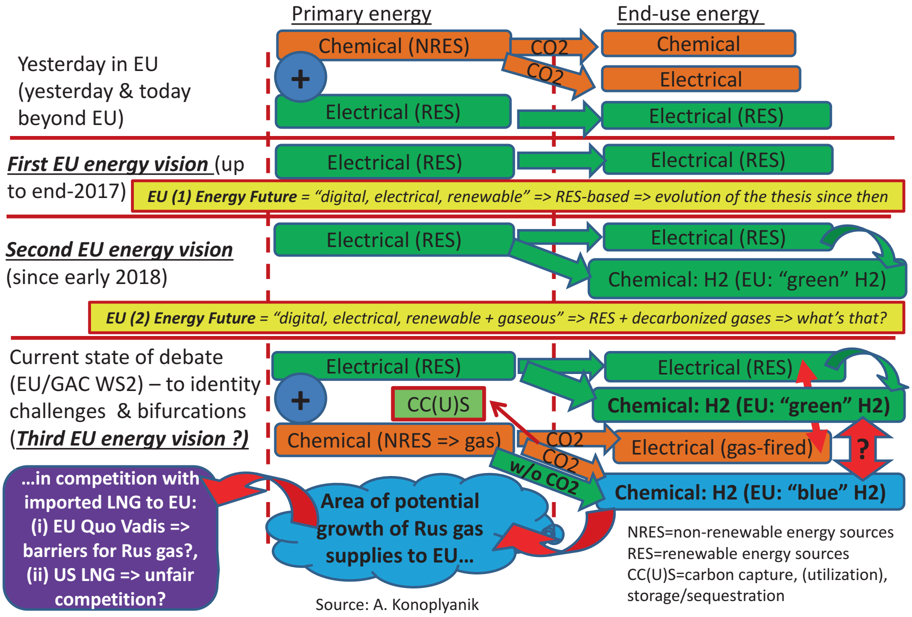


Fig. 11.12 Evolution of EU low-carbon policy/vision and prospects of Russia-EU cooperation within GAC WS2: challenges and bifurcations

From this author's view (cf. Konoplyanik, 2019h) this challenge appeared in January 2018 with the first public interview of the then Commission Director on Internal Energy Market (now Deputy Director General, DG ENERGY) Klaus-Dieter Borchardt (Borchardt, 2018). He stated that the previous vision within the EU of the bright energy EU future as 'digital, electrical, renewable' would be corrected to the new formula, meaning the same plus 'decarbonised gases'. This opened the door for and enabled the Russia-EU professional informal discussion on what Walter Boltz, co-chair of WS2 GAC from the EU side, has expressed as 'to find out how Russia can help the EU to move to its low carbon energy future' despite the quite different national priorities of Russia and the EU in this area. So the question is: how to find the common denominator between the two based on joint commercial interests while common technological denominator between Russia and the EU in energy, especially in gas, which closely unites both parties, has already existed for a long time. This is, as mentioned above, a technically joint/common cross-border capital-intensive long-distance immobile gas infrastructure.

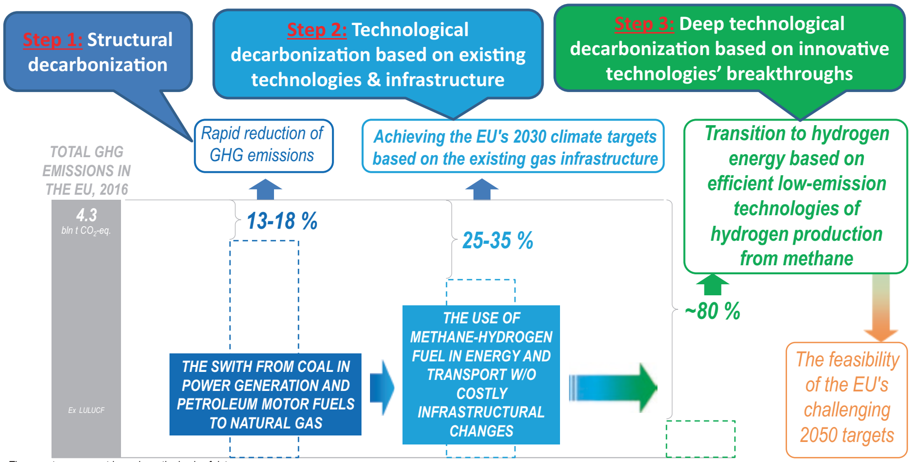
The current state of this discussion is to identity challenges and bifurcations within this 'Second EU energy vision'. Today the second, newly added, segment in the formula 'RES plus decarbonised gases' requires clarification. The option which seems to be of mutual benefit and which corresponds to W. Boltz's formula is to consider three key technological avenues of hydrogen production instead of only two which are considered today in most public debate within the EU. Those two are electrolysis (producing, in EU terminology, so-called 'green' hydrogen—from the water) and steam reforming (producing, in EU terminology, so-called 'blue' hydrogen—from natural gas). Electrolysis is ten times more energy intensive than hydrogen from methane production, and hydrogen produced is not clean if the electricity is taken from the grid (20% of EU electricity production is coal-fired). Steam reforming of natural gas resulted with CO_2 emissions; this means that CCS is relevant for this technology which adds 20–30% or even more to the cost budget (Konoplyanik, 2018f, 2019g).

The third, less frequently discussed, avenue is hydrogen production from natural gas without access of oxygen which means no CO_2 emissions. This might be the optimal way for Russia-EU cooperation since it could diminish the cost burden of decarbonisation on EU citizens, on the one hand, and will provide Russia to additionally monetise its vast gas resources under the EU decarbonisation scenario, on the other hand. Expansion from two to three technological avenues of hydrogen production and their treatment in a technologically neutral way (under principles of fair competition) might lead to the 'Third EU energy vision' which could create the fair basis for a mutually acceptable solution of 'how Russia can help the EU to move to its low carbon energy future' in the least costly way for the EU with increasing monetisation of Russian gas resources, thus improving welfare for both parties.

Having in mind three key technological avenues of hydrogen production, the following innovative low-emission methane-hydrogen scenario for the low-carbon EU energy future within its argued 'Third EU energy vision' can be presented, consisting both of 'structural' and 'technological' decarbonisation (Fig. 11.13):

1. *Step 1*: Structural decarbonisation;
2. *Step 2*: Technological decarbonisation based on existing technologies and infrastructure; and
3. *Step 3*: Deep technological decarbonisation based on innovative technological breakthroughs.

This author calls this proposed road map a 'three-steps of Gazprom's/Aksyutin's path' since it was worked out and publicly presented by Oleg Aksyutin, now Deputy CEO of Gazprom (Aksyutin, 2018; Aksyutin et al., 2018), including in Gazprom's comments to the European Commission



The expert assessment is made on the basis of data on:

- *Carbon intensity from different fuels (U.S. Energy Information Administration estimates);*
- *Carbon footprint of various motor fuels (European Natural gas Vehicle Association report, 2014-2015);*
- *EU GHG emissions (1990 – 2016 National report on the inventory of anthropogenic emissions by sources and GHG removals by sinks not controlled by the MontrealProtocol , IEA)*

SOURCE: Aksyutin (2018). Adapted from the European Commission (2018).

Fig. 11.13 Innovative low-emission methane-hydrogen scenario for the low-carbon EU energy future within its argued "Third EU energy vision": three-steps of Gazprom's/Aksyutin's path

Communication 'Strategy for long-term EU greenhouse gas emissions reductions' (European Commission, 2018).

Figure 11.14 presents the Russia-EU challenges and bifurcations for a low-carbon EU energy future, as seen by this author, which sets the agenda for WS2 GAC discussions on decarbonisation issues. It is argued here that we have passed within WS2 GAC through bifurcations N1 and N2. Bifurcation N3 remains as a topic for intensive further debate.

It is also argued here that we are very close to reaching mutual understanding in the WS2 GAC on bifurcation N4 (Fig. 11.15). 80% of CO_2 emissions within the Russia-EU cross-border gas value chain are downstream, at the consumer end and within the EU. This means that, as a sensible and mutually preferential option, decarbonisation downstream (at the point of end-use, within the EU, where most of the emissions occur) should be based on Russian gas export and (export of Russian and/or jointly developed, if commercialised and competitive) technologies of hydrogen production without CO_2 emissions. This should be based on fair competition, technological neutrality, mutual complementarity of 'blue' hydrogen technologies both with (Norway/Equinor's path, including CCS) and without CO_2 emission (Russia/Gazprom's path, without—since there is no need of—CCS).

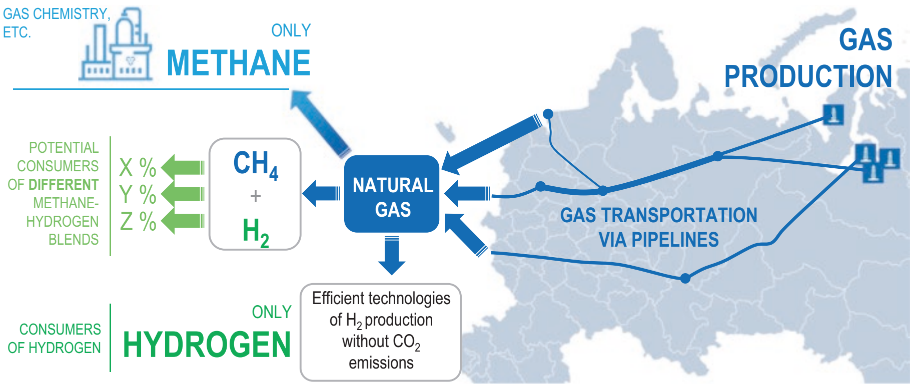
Further, it is argued here that this is where additional opportunities and new challenges for Russia/Gazprom in the EU as a result of decarbonisation

1) **All-electric (RES-based) *vs.* electric + gaseous (RES + decarbonised gases) EU energy future**
2) **RES + decarbonised gases: "RES (electricity) + RES (renewable gases)?** [(H2 = P2G = green H2 only) + biogases] ***vs.*** **RES (electricity) + RES (renewable gases) + non-renewable gases**
   a. Green H2 = **RES electricity** (available tech, but small & not-bankable), or
   b. "Green" H2 = **electricity from the grid** (available tech, but not green)
3) **RES + Decarbonised (renewable & non-renewable) gases: green H2 + blue H2 with CO2 *vs.* green H2 + blue H2 with/without CO2** => what "blue" H2 is?:
   a. Blue H2 **with** CO2 => CC(U)S needed => available tech, but more costly, less bankable (Norway's path)
   b. Blue H2 **without** CO2 => no need in CC(U)S => not yet commercialized tech for H2(*), but can be less costly (since no CC(U)S), more bankable => Russia's/Gazprom's path (three-steps "Aksyutin's path" - A.K.) => but in the common interests of both EU & Russia to jointly commercialize (now for H2 as main product) from current R&D?
4) **Where to decarbonize within cross-border gas value chain?: upstream *vs.* downstream**
   a. **Upstream** (in Russia) – not in multilateral interests
   b. **Downstream** (within the EU) – within multilateral interests

Green H2 (EU/CertifHy): generated by RES (Bio/Hydro/Wind/Solar) with carbon emissions 60% below the benchmark emissions intensity threshold (= GHG emissions of the hydrogen produced by steam reforming of natural gas representing 95% of current merchant market).
Blue H2 (EU/CertifHy): created by NRES (Nuclear electricity/Fossil with CC(U)S i.e. with to-be-utilized CO2) with emissions below the same threshold => **NOT considering Blue H2 without CO2 i.e. without CC(U)S (seems to be the general understanding within the EU)**
In both cases emissions shall be less 60% of medium industry levels (under steam reforming), so both green & blue H2 under EU definitions have the same limit of GHG emissions and same influence on climate (*) except 1998-2001 in Canada for black carbon

Source: A. Konoplyanik

Fig. 11.14 Low-carbon EU energy future & Russia-EU challenges & bifurcations: agenda for GAC WS2



SOURCE: Aksyutin, Ishkov & Romanov (2018)

Fig. 11.15 Selection of location for hydrogen production within Russia-EU gas value chain

of the European gas industry exist and 'how Russia can help the EU to move to its low carbon energy future'. It is quite clear to me that with our joint Russia-EU efforts in this area we can manage to reach better results for all.

References (All below-mentioned references of this author are available from his website www.konoplyanik.ru.)

Aksyutin, O. 2018. Future Role of Gas in the EU: Gazprom's Vision of Low-Carbon Energy Future. 26th Meeting of GAC WS2, Saint-Petersburg, July 7, 2018. www.fief.ru/GAC.

Aksyutin, O., Ishkov, A. and Romanov, K. 2018. Potential of Natural Gas Decarbonization: Russian View of the Cross-Border Gas Value Chain. 27th Meeting of GAC WS2, Brussels, December 7, 2018. www.fief.ru/GAC.

Borchardt, K.D. 2018. A Comprehensive View on the EU Energy Future from the EU Commission Director for Internal Energy Market. Florence School of Regulation, January 22, 2018. https://www.youtube.com/watch?v=N7GBa3YyYKY&feature=youtu.be.

BP. 2015. BP Technology Outlook. Technology Choices for a Secure, Affordable and Sustainable Energy Future, November 2015. https://www.bp.com/content/dam/bp-country/de_ch/PDF/technologie/BP-Technology-Outlook.pdf.

BP. 2017. BP Statistical Review of World Energy, June 2017. https://www.bp.com/content/dam/bp-country/de_ch/PDF/bp-statistical-review-of-world-energy-2017-full-report.pdf.

BP. 2019. BP Statistical Review of World Energy 2019: An Unsustainable Path, June 2019. https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-statistical-review-of-world-energy-2019.html.

Bushuev, V.V., Konoplyanik, A.A. and Mirkin, Y.M. 2013. *Oil Prices: Analysis, Trends, Forecast*. Energiya Publishing House (in Russian).

Chevalier, J-M. 1973. *Le nouvel enjeu petrolier*. Paris: Calman-Lévy.

Chevalier, J-M. 1975. *Oil Crisis*. Moscow: Mysl Publishing House (In Russian).

Dale, S. 2017. BP Energy Outlook 2017: Presentation in IMEMO RAS at the 'Oil & Gas Dialogue' Seminar, February 7, 2017.

Energy Charter Secretariat. 2007. Putting a Price on Energy: International Pricing Mechanisms for Oil and Gas. https://energycharter.org/fileadmin/DocumentsMedia/Thematic/Oil_and_Gas_Pricing_2007_en.pdf.

European Commission (EC). 2018. PJSC Gazprom's Feedback on Strategy for Long-Term EU Greenhouse Gas Emissions Reduction to 2050. https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-3742094/feedback/F13767_en?p_id=265612

Hotelling, H. 1931. The Economics of Exhaustible Resources. *Journal of Political Economy* 39(2): 137–175.

Hubbert, M.K. 1949. Energy from Fossil Fuels. *Science* 4(109): 103–109.

Hubbert, M. K. 1956. Nuclear Energy and the Fossil Fuels. Presented before the Spring Meeting of the Southern District Division of Production American Petroleum Institute Plaza Hotel, San Antonio, Texas March 7–9, 1956. Publication No. 95, Shell Development Company, Exploration and Production Research Division (Houston, Texas, June 1956).

IEA. 2012. World Energy Outlook 2012: Executive Summary. https://www.iea.org/publications/freepublications/publication/English.pdf.

Konoplyanik, A. 2004. Energy Security and the Development of International Energy Markets. In: Barton, B., Redgwell, C., Ronne, A. and Zillman, D.N. (Eds.) *Energy Security: Managing Risk in a Dynamic Legal and Regulatory Environment*. Oxford: International Bar Association/Oxford University Press, pp. 47–84.

Konoplyanik, A. 2013a. Global Oil Market Developments and Their Consequences for Russia. In: Goldthau, A. (Ed.) *The Handbook of Global Energy Policy*. Wiley-Blackwell Publication, Chapter 28: pp. 477–500.

Konoplyanik, A.A. 2013b. The Unipolar Oil World Is a Real Prospect. Economic Policy: Expert Channel, September 5 (in Russian).

Konoplyanik, A.A. 2013c. The Evolution of Oil and Gas Markets: Patterns of Movement from Physical Markets to Paper Energy Markets. In: Makarov, A.A. (Ed.) *The Seventh Melentiev Readings*. Collect. Sci. Proc. Moscow: Institute for Energy Research RAS, pp. 163–178, 2013. (in Russian).

Konoplyanik, A. 2013d. Alternative Investment Regimes for Direct Foreign and Domestic Investments in Russian Subsoil. *The Harriman Review Occasional Paper* 19(1).

Konoplyanik, A.A. 2014a. American Shale Revolution: The Consequences Are Inevitable. *ECO* 5: 111–126 (in Russian).

Konoplyanik, A. 2014b. Economic Background of the Gas Problems Within the Triangle Russia—The EU—Ukraine and Possible Ways to Solve Them. Institute for Macroeconomic Forecasting RAS, Open Scientific Seminar 'Economic Problems of Energy Industries (A. S. Nekrasov Seminar),' 152th Meeting, October 21, 2014, Moscow, 2014 (in Russian).

Konoplyanik, A. 2015a. Whether Low Oil Prices Put an End to Oil Indexation in Gas? What Are Alternative Ways & Means to Obtain Maximum Marketable Resource Rent in Term Gas Contracts? Presentation at the 8th ENERGETIKA-XXI: Economy, Policy, Ecology International Conference (Saint-Petersburg, 11–12 November, 2015).

Konoplyanik, A.A. 2015b. 'Kudrin's Scissors,' Siluanov's 'Sickle,' What's Next? *Oil of Russia* 10: 18–24 (Part 1); 11–12: 10–15 (Part 2) (in Russian).

Konoplyanik, A.A. 2015c. Accounting Arithmetic or Development Economics: Budgetary Problems from the Point of View of Taxation of the Oil and Gas Industry. 'NG-Energy' Monthly Supplement to 'Nezavisimaya Gazeta,' October 11, 2015 (in Russian).

Konoplyanik, A.A. 2015d. To the Agenda of the Presidential Commission on Energy. *Oil and Gas Vertical* 20: 52–55 (in Russian).

Konoplyanik, A. 2016a. The US Shale Gas Revolution and Its Economic Impacts in the Non-US Setting: A Russian Perspective. In: Hunter, T. (Ed.) *Handbook of Shale Gas Law and Policy*. Intersentia, pp. 65–106.

Konoplyanik, A. 2016b. The Paris Climate Agreement (COP-21): New Challenges for the Global and Russian Energy Industry. Invitation to Discussion. Presentation at a Meeting of the Academic Council of the Institute for Energy and Finance Foundation, Moscow, December 15, 2016 (in Russian).

Konoplyanik, A. 2016c. US LNG vs Russian Pipeline Gas in the EU: To Get Rid of the Rival? Presentation at the Free Webinar 'US LNG and European Gas Market,' Organized by Vostok Capital Prior to 'LNG 2017 Congress Russia', Moscow–London, October 26, 2016.

Konoplyanik, A. 2017a. Counter 'Domino Effects'. *Oil of Russia* 5–6: 4–11 (in Russian).

Konoplyanik, A. 2017b. EU 'Sanitary Cordon' on the Way of Hydrocarbons (Attempts to Regulate European Market of 'Blue Fuel' Leads to the Limitations of Presence of Domestic Companies in the 'Old World'). NG-Energy', Monthly Supplement to 'Nezavisimaya Gazeta', October 10, 2017, 12–13 (in Russian).

Konoplyanik, A. 2017c. Clearing of the Market: How They Would Like in the EU to Change the Rules of Purchasing Russian Gas. *RBC-Daily*, July 31, 2017 (in Russian).

Konoplyanik A. 2017d. One Way Drive. *Oil and Gas Vertical* 15–16: 52–57 (in Russian).

Konoplyanik, A. 2017e. EU Quo Vadis: A Theoretical Exercise with an Anti-Russian Flavour? *Global Gas Perspectives*, October 19.

Konoplyanik, A. 2017f. Quo Vadis: An Assessment of the Efficiency of the Third Energy Package or Preparation of the New 'Curzon Line'? *Oil, Gas and Law* 4: 42–53; 5: 47–56; 6: 51–59 (in Russian).

Konoplyanik, A. 2017g. An Assessment of the Efficiency of Implementation of the Third EU Energy Package and the European Commission's Project Quo Vadis. *Gas Industry Special Issue* 4(75): 36–46 (in Russian).

Konoplyanik, A.A. 2018a. A View on the Evolution of Russia's Gas Export Strategy Within Changing Global Economic and Gas Landscape. Presentation at the 'GECF Monthly Gas Lectures' Series, Gas Exporting Countries Forum (GECF), Qatar, Doha, October 15, 2018.

Konoplyanik, A.A. 2018b. A View on the Evolution of Russia's Gas Export Strategy Within Changing Global Economic, Political & Gas Landscape. Presentation at the 3rd World Gas & LNG Conference-Exhibition, 'Novotel Sheremetievo' Hotel, Moscow, Russia, October 18–19.

Konoplyanik, A. 2018c. Positive Discrimination: What Is the Role of LNG from the USA on the European Gas Market. *RBC-Daily*, October 23, 2018 (in Russian).

Konoplyanik, A. 2018d. Liquefied Gas—A New Geopolitical Factor (The US Is Trying to Use Blue Fuel to Strengthen Its Dominance in the World). 'NG-Energy' Monthly Supplement to 'Nezavisimaya Gazeta', November 13, 2018, pp. 12–13 (in Russian).

Konoplyanik, A. 2018e. The LNG Market Is a Driver of Change (The Development of Trade in Liquefied Natural Gas Leads to Significant Transformations in the

Economic and Political Spheres). *Oil and Gas Vertical* 23–24: 37–44 (Part 1 of a Cycle of Four Articles) (in Russian).

Konoplyanik A. 2018f. Russian Gas: Why New Pipelines to Europe Are Needed. Presentation at the American Chamber of Commerce Energy Committee Meeting, Moscow, April 10, 2018.

Konoplyanik, A. 2018g. Russian Gas to Europe: From the Linear (Radial) to the Radial-Ring Supply System—And the New Role of Transit. Presentation at the 14th Russian Oil and Gas Congress (RPGC) as Part of the 15th International Exhibition 'Oil and Gas' (MIOGE), Moscow, June 19, 2018 (in Russian).

Konoplyanik, A. 2018h. Evolution of the Russian Gas Strategy in the European Direction in the Context of Changes in the International Gas Markets and in Global Competition (see the Author—An Invitation to the Discussion). Presentation at the Conference-Seminar 'Global and Local Markets of Oil, Gas and Petroleum Products: Analysis and Forecasting, Pricing, Trade Flows', Moscow, September 20, 2018 (in Russian).

Konoplyanik, A. 2018i. Fourth EU Energy Package? What Gazprom Should Be Prepared for in Europe. *Oil and Gas Vertical* 3: 26–36 (in Russian).

Konoplyanik, A. 2018j. EU's Fourth Energy Package. Gazprom in Europe: What to Prepare For. *Oil and Gas Vertical* 2(4): 16–25.

Konoplyanik, A. 2018k. On Competitive Markets and Anti-competitive Behavior on the Example of US LNG Against Russian Pipeline Gas in Europe. *Energy Policy* 6: 18–27 (in Russian).

Konoplyanik, A. 2019a. From New Record to New Normality? To the Results of the Poll of Gas Industry Representatives at the 12th European Gas Conference. *Oil and Gas Vertical* 5: 70–77 (in Russian).

Konoplyanik, A. 2019b. New Russian Gas Export Record to Become a New Standard. *Global Gas Perspectives*, March 20, 2019.

Konoplyanik, A. 2019c. When America Is Always First and Foremost… (Attempts to Squeeze Russian Gas Out of Europe in Favor of American LNG Have an Exclusively Pragmatic Economic Background on the Part of the United States and Its Political Implementation Tools). *Oil and Gas Vertical* 1–2: 87–94 (Part 2 of the Cycle of Four Articles) (in Russian).

Konoplyanik, A. 2019d. The Great Milestones. How Washington Is Trying to Promote Its LNG to Europe and Prevent the Russian Pipeline Gas from Reaching There. *Oil and Gas Vertical* 3–4: 60–68 (Part 3 of the Cycle of Four Articles) (in Russian).

Konoplyanik, A. 2019e. Hacking in to Europe. The United States Are Using Any Means to Push Its LNG into the European Gas Market. *Oil and Gas Vertical* 5: 61–69 (Part 4 of the Cycle of Four Articles) (in Russian).

Konoplyanik, A. 2019f. Prospects of Further Monetization of Russian Gas in the European Direction, Obstacles on this Way and Possibilities to Overcome Them. Master-Class at the Programme 'Oil & Gas Trading', Module 5 'Natural Gas &

LNG', School of International Business of Russian State Gubkin Oil & Gas University, Moscow, May 31, 2019 (in Russian).

Konoplyanik, A. 2019g. On the Prospective Role of Russian Natural Gas in EU Decarbonisation. Presentation at the 'Energy Transition Forum', IENE/ECE, Vienna, June 6–7, 2019.

Konoplyanik, A. 2019h. Evolution of EU Low-Carbon Policy/Vision—And Prospects of Russia-EU Cooperation Within GAC WS2: Challenges & Bifurcations. 28th GAC WS2 Meeting, Brussels, ENTSOG, March 29, 2019.

Konoplyanik, A. and Borchardt, K.D. 2018. The EU, Russia and the Fair Gas Trade Debate. *Global Gas Perspectives*, July 6, 2018.

Konoplyanik, A. and Sung, J. 2016. Does American LNG Have a Chance? The Fall in Oil Prices Has Led to a Change in the Balance of Competitiveness of the Two Pricing Models for Liquefied Gas in the APR Countries. *Oil of Russia* 5–6: 11–19 (in Russian).

Konoplyanik, A., Buzovsky, V., Popova, Yu. and Troshina, N. 2015. The Impact of Anti-Russian Sanctions on the Development of the Oil and Gas Potential of the Russian Arctic Shelf—And the Bifurcation of Russia's Energy Policy // M., Vostok Capital 2015 (in Russian).

Kopytin, I. 2011. Oil Price Risks. Scientific Practical Conference Gazprombank—IMEMO RAS 'Oil as a Special Class of Assets—Current Trends and Risks', Moscow, November 13, 2011 (in Russian).

Kuhn, M. and Romanov, K. 2017. Comments on the DBI Study and Further Joint Actions Proposals on Carbon Track. Presentation at the 22nd meeting of the EU-Russia Gas Advisory Council, Vienna, February 14, 2017.

Kurenkov, Yu. and Konoplyanik, A. 1985. Dynamics of Production Costs, Prices and Profitability in the Global Oil Industry. *World Economy and International Relations* 2: 59–73 (in Russian).

Meadows, D.H., Meadows, D.L., Randers, J. and Behrens III, W.W. 1972. *The Limits to Growth. A Report to The Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books, A Potomac Associates Book.

MIT. 2011. T*he Future of Natural Gas. An Interdisciplinary MIT Study*. Cambridge, MA: MIT Press, p. 163.

Müller-Syring G., Große, Ch., Eyßer, M. and Glandien, J. 2017. Carbon Footprint of Natural Gas Critical Evaluation of Default Values for the GHG emissions of the Natural Gas Supply Chain. Presentation at the 22nd meeting of the EU-Russia Gas Advisory Council, Vienna, February 14, 2017. https://www.dbi-gut.de/emissionen.html?file=files/HIPS_net/Emissionen/Finale%20Dokumente/Presentation_english.pdf.

Neha, K. 1973. On the Economics of Non-renewable Resource, in 'Economics Interactions with Other Disciplines. In: Gowdy, J.M. (Ed.) *Encyclopedia of Life Support Systems (EOLSS)*. Oxford: Eolss Publishers. http://www.eolss.net.

Prins, N. 2014. *All the President's Bankers. The Hidden Alliances that Drive American Power*. New York: Nation Books, Perseus Books Group.

The Economist. 2003. The Future of Energy: The End of the Oil Age, October 23, 2003. https://www.economist.com/leaders/2003/10/23/the-end-of-the-oil-age.

The Economist. 2012. Gas Works: Shale Gas Is Giving a Big Boost to America's Economy. *The Economist*, July 12, 2012. https://www.economist.com/special-report/2012/07/12/gas-works?FEATURE_ARTICLES_V1=0.

The Economist. 2013. The Father of Fracking: Few Business People Have Done as Much to Change the World as George Mitchell. *The Economist*, August 3, 2013. https://www.economist.com/business/2013/08/03/the-father-of-fracking.

UNFCCC. 2015. Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

Yergin, D. 1991. *The Prize. The Epic Quest for Oil, Money & Power*. New York: Free Press.

Zhukov, S.V. 2011. Oil as a Financial Asset. Scientific Practical Conference Gazprombank—IMEMO RAS 'Oil as a Special Class of Assets—Current Trends and Risks', Moscow, November 13, 2011 (in Russian).

Zhukov, S. and Zolina, S. 2016. USA: Financial Markets and the Development of Non-conventional Oil Sector. *World Economy and International Relations* 60(11): 14–24 (in Russian).

12

The Role of German Regime Actors and Trade Unions in the Energy Transition: Agency and Power

Stefan Bößner

1 Introduction and Approach

The German energy system is in the middle of a significant overhaul. Nuclear power is to be phased out, emissions are to be reduced considerably and renewable energies are set to replace a fossil fuel-based electricity system. This transformation of the energy system, usually referred to as *Energiewende*, has gathered some significant international attention, especially since its results are quite paradoxical. While Germany has been quite successful in increasing the share of renewables, the greenhouse gas (GHG) emissions of the EU's largest economy remain stubbornly high. The main reason for this failure is the prominent role coal has played and continues to play in the German economy for a number of historic, economic and socio-cultural reasons. Indeed, norms, practices and behaviours associated with these reasons contribute to a stable fossil fuel-based regime which jeopardises German climate ambitions. This chapter will look at the reasons of Germany's continuous love affair with coal and gauges the positions and arguments of two prominent coal stakeholders, the German utilities and German trade unions. This chapter will analyse their role by giving special consideration to concepts of agency and power, two concepts that are often neglected in the literature on energy transitions.

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2 Understanding Energy Transitions: Useful Theories and Frames

2.1 The Multi-Level-Perspective (MLP)

During the past decade, literature on how to understand energy transitions has exploded, shedding light on the phenomenon form different perspectives. Some take a governance perspective (Kuzemko et al., 2016; Meadowcroft, 2009), some look at the specific policies needed to facilitate those transitions (Rosenow et al., 2017; Rogge and Reichardt, 2016) while others look at the innovation aspect (Grubb et al., 2017) or at how specific technologies impact energy and electricity markets (Tveten et al., 2013).

This chapter will take a multi-level perspective (MLP), a well-established theory to understand energy transitions and particularly relevant in the German context. MLP proposes three levels: the niche, the regime and the landscape (Geels, 2002; Geels and Schot, 2007). The 'landscape', the top level, is the context through which the other levels are to be understood and offers the cultural, socio-economic, technological and even ideological background (Geels and Schot, 2007; Geels, 2011). Changes on the landscape level usually happen only slowly (Geels and Schot, 2007). International energy markets based on free trade would be one example of this landscape. Below the landscape (and influenced by it) sits the 'socio-technical regime'. The regime is a set of norms, rules and behaviours that account for a stable, socio-technical system (Geels, 2011). Actors of the regime form well-connected, strong networks and institutions of the regime usually guarantee system stability or even lock-in of certain practices (Smith et al., 2010). In the energy context, a centralised, fossil fuel-based electricity system with its infrastructure, actors and institutions neatly set-up to cater to its needs would be an example of a regime. The last level is the 'niche', where innovation is pursued but which does not enjoy the same solid networks and actor relationships as the regime (Geels, 2011). Niches can be protected by special policies in order to shield nascent innovative technologies from competition with the regime, a practice often referred to as strategic niche management (Schot and Geels, 2008). In this example, de-centralised renewable energy solutions would be part of the niche.

The relationship of those levels is highly dynamic: The niche often exercises pressure on the regime while the regime is in turn influenced by landscape developments (Geels and Schot, 2007). When a window of opportunity opens (Geels, 2011), pressure from the niche can either lead to the regime incorporating (or conforming) niche technologies in its existing structure or to the replacement of the regime with a new institutional set-up and its own rules and norms based on (formerly) niche technologies (Geels, 2011). While these dynamics are fluctuating and different stages of a given transition may exhibit different niche-regime dynamics (Geels et al., 2016) this competition between niche and regime is very useful to keep in mind when looking at the German energy transition context because of the strength of its regime (see section 5).

However, criticism of MLP has often deplored that the theory cannot really account for notions like power or agency (Smith et al., 2005). While MLP scholars have denied and responded to this criticism (Geels, 2011), MLP is arguably better suited to frame the dynamics of energy transitions than to explain agency of power of the actors involved. This chapter will supplement MLP literature with some reflections on power and agency.

2.2 The Power and Agency of Stakeholders

As Raven et al. (2016) point out, aspects of power and agency are somewhat under-researched in the fields of innovation and transition studies (Raven et al., 2016). However, it seems to be clear that not every actor involved in a transition pathway has the same capacity (or agency) to influence it. Agency, for that matter, is often understood as being able to make a difference to a pre-existing state (Giddens, 1984) based on interactions with fellow human beings (Burkitt, 2016) or, as Taylor et al. (2017: 2) put it: "*the active behavioural response to social, political and economic incentives*".

Power, on the other hand, is a significantly older concept, anecdotally dating back to the Greek thinker Thucydides, often quoted by international relations scholars, who defines power as "[…] *the strong do what they can while the weak suffer what they must*" (Thucydides and Crawley, 1910). Max Weber refined the definition of power as the capacity to force one's will onto someone else (Weber, 1922) while Hannah Arendt put emphasis on the communicative aspect of power which is exercised when convincing others to act together for the same objective (Arendt, 1995). For this chapter it is fruitful to employ a more recent concept of power based on Avelino and Rotmans (2009) who define power as the ability of stakeholders to mobilise resources to achieve a certain goal, be it collective or out of self-interest (Avelino and Rotmans, 2009). Those resources are human resources (labour, actual people), mental resources (such as knowledge or even ideologies), monetary resources, artefactual resources (infrastructure like power plants etc.) and natural resources (forests, land) (Avelino and Rotmans, 2009). While one might assume that monetary or human resources are more useful (or powerful), it is worth noting that mobilising mental resources such as ideologies or knowledge must not be underestimated. Indeed, Geels himself argues that the power of 'framing'—i.e. the construction of meaning by focusing attention on certain aspects of a problem (Snow, 2013)—plays a significant role in low carbon transitions (Geels, 2014). By setting the agenda and by shaping what kind of issue can be discussed, framing does not only guide discussion but might also provide a certain 'lock-in' of solutions. For instance, framing the energy transition as an energy security issue rather than an environmental or climate issue might generate a different kind of discussions with specific sets of solutions proposed that are perhaps absent in environmental or climate frames. As a proverb puts it, if all you have is a hammer, every problem looks like a nail.

It is both possessing these resources such as framing capacity, human resources or money and the ability to mobilise those resources that makes stakeholders powerful (Avelino and Rotmans, 2009). As we will see, it is this resource mobilisation capacity of German regime actors which makes the country's love affair with coal so enduring.

3 The German *Energiewende*: Ambition, Reality and the Neglected Role of Coal

The German energy transition is a series of laws and strategies to significantly transform the German energy system, from a carbon-intensive to a low-carbon one. The roots of the German *Energiewende* date back to the 1980s, when a German environmental think tank coined the term (Strunz, 2014) but the true boost to transforming the German energy system came in 2000. The then government, formed by the Socio-Democratic party and the Green party (the second of such 'red-green' governments in Europe), decided to phase out nuclear power (a policy later confirmed after the 2011 Fukushima disaster to happen by 2022) and to adopt the flagship law of the German energy transition: The *Erneuerbare-Energien-Gesetz* (EEG), the renewable energy act. This law, which has attracted significant scholarly attention (Krewitt and Nitsch, 2003; Lauber and Jacobsson, 2016), put into place fixed remuneration schemes for renewable energy producers and an obligation for this green electricity to be treated preferentially on the grid. Later, in 2010, the German Government presented another milestone, its *Energiekonzept*, the strategic vision of Germany's energy policy which envisions GHG emission

Table 12.1 The German energy transition objectives[a]

	2020	2030	2040	2050	Status quo in 2017
Two overarching objectives					
Nuclear phase out	Phase out by 2022		No nuclear power		
GHG emissions (compared to 1990)	−40%	−55%	−70%	−80–95%	−27.7%
Renewable energies					
Share in gross final energy consumption	18%	30%	45%	60%	14.8% (in 2016)[b]
Share in gross electricity consumption	35%	50%	65%	80%	36.2%[c]
Energy efficiency					
Primary energy consumption (compared to 2008)	−20%			−50%	−5.9%[d]

[a]Table adapted from Kemfert et al. (2015)
[b]Eurostat (2018)
[c]Umweltbundesamt (2015)
[d]Eurostat (2018)

reductions of up to 95% by 2050 (Kemfert et al., 2015) and despite adjustment made to its legislation, the overall gist of the *Energiewende* can be described as follows.

Two overarching goals are defined: Germany's nuclear capacity will be phased out by 2022 and the country's emissions should decrease by 40% compared to 1990 levels in 2020 and by 80–95% by 2050 (Bundesministerium für Wirtschaft und Energie, 2018). In order to achieve this, two strategies are employed. The share of renewable energy sources (RES) should rise to 18% of final energy consumption by 2020 and energy consumption should be reduced by 20% by the same date. Those 'sub-objectives' should be realised in the electricity, heat and transport sectors. Table 12.1 gives an overview of the energy transition's objectives and the targets per sector.

Two observations can be made at this point. First, the German energy transition does have a much more complex architecture than usually reported, going beyond renewables deployment in the electricity sector and is more of a turnaround—the better translation for the German term *Wende*—than a transition. Indeed, the feat of shifting from a system of centralised, fossil-fuel based electricity produced in large power plants towards a decentralised, smaller scale electricity system where citizens and cooperatives own a significant share of capacity,[1] should not be underestimated, particularly in a country

[1] Indeed, one peculiarity of the German energy transition is its participatory nature. It is estimated that 42% of all renewables installations in Germany are owned by individuals or cooperatives, often summarised under the term *Bürgerenergie* (citizen energy) (Heinrich Böll Stiftung, 2018).

which derives around 28% of its GDP from the industrial sector (way above the EU average of 22% (World Bank, 2018)).

Second, from these figures it is clear that the German energy transition, measured only against its primary objectives, is less successful than hoped. Emissions remain stubbornly high as does energy consumption and while the share of renewables in the electricity sector is impressive, lagging sectors such as transport and heat might make Germany miss its overall renewable energy target. But it is the high GHG emissions which are a particular headache for German policy makers and for the credibility of the German energy transition abroad (Hockenos, 2017).[2] The main cause is the important role coal still plays in the German energy sector and indeed in its economy, a factor which has been long ignored during the country's energy transition policy making.

4 Coal in Germany: A Rich History

Coal, which can be divided into hard and brown coal (also called lignite), is usually considered the most polluting fossil fuel since its chemical composition makes it release more CO_2 compared to other fossil fuels such as gas when burnt (EIA, 2018). Although a full life cycle assessment of the emissions from different power plants on different time scales nuances this picture—clearly demonstrating that all fossil fuels are harmful to the environment (Busch and Gimon, 2014)—coal is particularly unsustainable, with lignite being even more harmful than hard coal. In addition to the quite considerable damages to the environment in and around mining regions, coal, when used to generate power, also has some significant negative health impacts. Grey literature argues that in Europe alone, more than 22,000 people die prematurely each year due to pollution from coal power. The majority of those polluting power plants are found in Poland, but also Germany (Jones et al., 2016).

The role of coal in the Germany energy sector and for the German economy as a whole is best understood by applying several analytical prisms in a historic perspective.

4.1 The Socio-Cultural Perspective

Examining transition pathways from a socio-cultural perspective (i.e. examine lifestyles, practices and traditions) can greatly enrich our understanding as

[2] It is important to note that particularly the Anglo-Saxon media have taken a liking to criticising the German energy transition, often using quite unbalanced arguments.

opposed to a strictly socio-technical analysis (Chiesura and de Groot, 2003). For instance, research on coal transition has shown that coal regions often create strong narratives around the mining and treatment of coal thus creating strong cultural identities (Caldecott et al., 2017). For those coal intensive regions, coal is not just a fossil fuel but has additional, intrinsic value such as increasing the region's self-esteem and the identities of professional and family networks in those regions are heavily influenced by coal. While it is noteworthy that this regional identity can also be constructed based on the opposition to new or expanding coal mines (Frantal, 2016) and that those identities might be (mis)used by powerful regime players to gain influence over this identity (Bell and York, 2010), coal has been historically important for Germany.

When the industrial revolution kicked off, almost 95% of energy needs in Europe were met with coal (Hobsbawm, 1987: 26). Use of the coal powered steam engine exploded in Germany which reached about 900,000 HP (horse power) by 1870 or about the same as the then economic powerhouse Britain (Hobsbawm, 2012: 55). Coal workers played an important role in the formation of German labour and trade unions who enjoyed relative influence, not surprisingly since by around 1907, 800,000 people were employed in the coal mining sector throughout the German empire (Hobsbawm, 1987: 115, 122). Moreover, Germany's oldest political party, the centre-left Social Democratic Party (SPD) has its roots in the first union-like workers movement, the *Allgemeiner Deutscher Arbeiterverein* (ADAV) (Hobsbawm, 2012: 137), thus establishing early on a close relationship between the German centre-left parties and the German workers and trade unions.

After the second world war, Germany's relationship with coal acquired a distinct European dimension. It is useful to remind the reader less well-versed in European integration that the political and economic project which later became the European Union (EU) had its roots in the European Coal and Steel Community (ECSC), a joint initiative to collaboratively manage the coal and steel reserves of its six founding members in order to foster economic integration and avoid trade conflicts and ultimately another catastrophic war (Judt, 2005: 156f). So while coal was at the heart of European integration—which itself is often thought of as being driven by a French-German motor (Baun, 1995)—within Germany, coal was also hugely important for the economy and the economic boom which is commonly referred to as *Wirtschaftswunder*, the economic miracle of post-war Germany.

4.2 The Economic Perspective

Lignite production surged from 202 million tonnes in 1950 to about 432 million tonnes in 1985, an all-time high, while hard coal reached 81 million tonnes by the same date (STATISTA, 2018). Quite logically, the coal industry employed a significant number of people at its height, roughly 600,000 in the 1950s and 1960s (STATISTA, 2018) and was therefore an important economic factor. Coal represented a cheap and abundant energy source which was needed to fuel the German economy—heavily based on industry and manufacturing after the second world war—which did not have sufficient funds to source the raw material from abroad (Van Hook, 2004). Indeed, coal was deemed so important for the German economy that when the mining industry entered a period of crisis in the late 1950s, German policy makers subsidised coal mining and production with 17.1 billion Deutsche Mark (DM) between 1958 and 1967 which would amount to about €40 billion in today's money when adjusted for inflation (Gerlach and Ziegler, 2015).

But coal as an economic factor and as important as it was historically, has been in decline in recent years. Figure 12.1 graphically portrays the level of

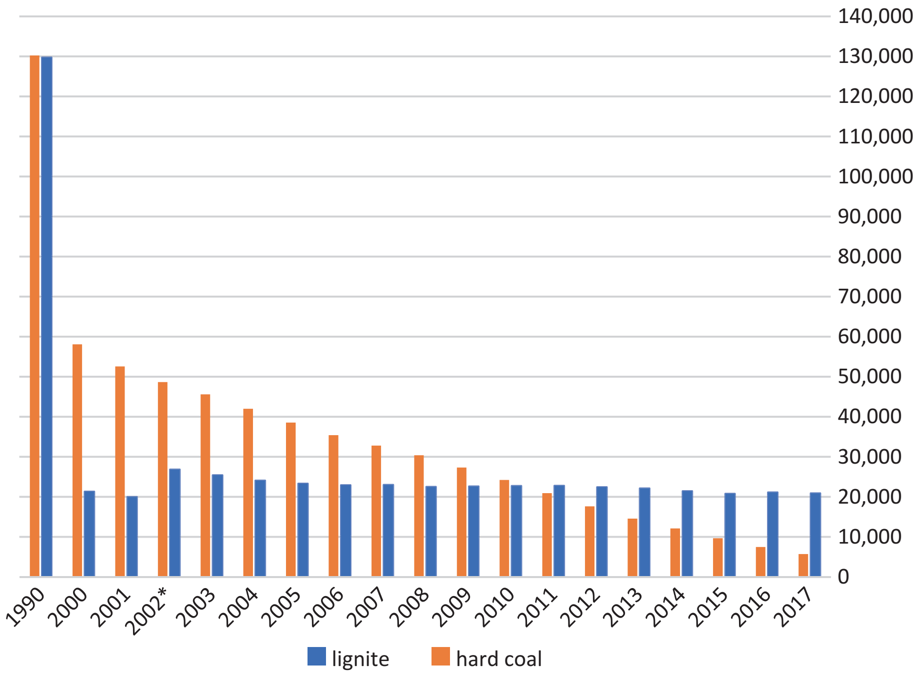

Fig. 12.1 Employment in the German coal industry between 1990 and 2017. Right-hand legend represents number of people employed. (Source: Adapted from STATISTA, 2018. © Stefan Bößner (author))

employment in the German coal industry between 1990–2017. As of 2017, there are less than 27,000 people employed in the German coal industry (STATISTA, 2018). Since 2002, this value also includes people working in power plants and non-mining personnel.

This downward trend can also be observed in the turnover of coal mining companies. While German hard coal and lignite miners achieved a turnover of roughly €4 billion in 2008, a few years later, in 2014, this had slipped to €2.2 billion (STATISTA, 2019).

However, both types of coal are not on the same trajectory. While hard coal production dropped to 3.6 million tonnes in 2017, brown coal production even increased to around 171 million tonnes, up from 167 million tonnes in 2000 (STATISTA, 2018). This is mainly due to the fact that while lignite is alive and kicking in Germany, the country had decided the fate of its hard coal ventures as long ago as 2007.

That year, Germany adopted a law to phase out federal subsidies for hard coal, bowing both to pressure from the EU and market forces. On the one hand, state aid and subsidies are generally forbidden under Article 107 of the Treaty of the Functioning of the European Union (TFEU)[3] and therefore had to be phased out. On the other hand, producing hard coal in Germany is almost three times more expensive as importing it (Umweltbundesamt, 2015). Without subsidies, Germany's hard coal industry was therefore doomed; however, this does not mean that the industry has not received any subsidies since. On the contrary, even two years before the phase-out, hard coal mining still received €1.3 billion in federal subsidies (Umweltbundesamt, 2017).

The lignite industry has not yet followed the same path for at least two reasons. First, while the industry usually does not divulge their production costs (Öko-Institut, 2017a), the Fraunhofer institute calculated that electricity generated from lignite power plants in March 2018 would cost between 4.59 and 7.9 €cents/kWh, traditionally one of the cheapest power sources in Germany (Kost et al., 2018). With German power prices on wholesale markets declining from an annual average of €51.6 euro/MWh in 2011 to €32.9 euro/MWh in 2017 (Fraunhofer ISE, 2016), this means that coal can still be profitable although a recent surge in EU emissions allowance prices and other climate policies seem to recently put pressure on coal as well (Marcacci, 2018). Second, and unlike hard coal, lignite's high moisture and volatile content make it uneconomic to transport which is why the import and export of lignite between the countries of the EU is close to zero and all lignite mined is

[3] In 2010, Decision 2010/787/EU specified that all subsidies to hard coal mines should be phased out by 2018.

consumed nationally (Ioakimidis et al., 2011) thus shielding it from external competition.

Given the county's farewell to hard coal, it makes sense to dig deeper into the role of lignite. From an economic perspective, it is important to note that the lignite industry is a quite localised endeavour in Germany. For instance, almost all mining activities in the 12 German mines (and therefore the lion's share of employment) are to be found in just three regions: The Rheinland, Lausitz and Mitteldeutschland. Table 12.2 provides an overview.

This geographic concentration is one of the main problems of the German lignite industry. While the above-mentioned figures of turnover or employment reveal that, overall, coal is becoming increasingly marginalised and eclipsed by renewable energies in Germany—to compare, 321,800 people worked in the German renewables industry in 2016 (EurObserv'ER, 2017)—coal still plays an important role in local economies.

In the regions mentioned in Table 12.2, coal mining or coal power is an important employer which regularly leaves politicians and trade union leaders to warn that if lignite was to be phased out in those region, a 'social blackout' (*Sozialer Blackout*) would follow (Fröhlich, 2015). Moreover, coal companies are not only employers but also drivers of the local economy by demanding auxiliary services and infrastructure which in turn has created and maintains jobs indirectly dependent on the coal industry. For instance, the Joint Research Centre of the European Commission argues that when considering inter-regional supply chains, the number of coal dependent jobs would be about 48,000 in Germany (Alves Dias et al., 2018). In the same vein, playing with those numbers allowed Vattenfall, before it sold its lignite operations in Germany, to claim that in the Lausitz region alone, the company's activities would guarantee 33,500 direct and indirect jobs (Bößner, 2016).

However, it is important to note that those figures are highly contested. Studies commissioned by the industry itself often exaggerate the potential of indirect job losses and methodologies of studies and their results vary (Öko-Institut, 2017b). This makes it difficult to estimate the real socio-economic impacts of coal on local economies and potential negative consequences of a

Table 12.2 The three largest lignite regions in Germany as of 2017

Region	Reserves	Production	Employment
Rheinland	51 billion tonnes	91 million tonnes	9,739
Lausitz	11.6 billion tonnes	61 million tonnes	8,639
Mitteldeutschland	10 billion tonnes	18 million tonnes	2,367
Total (incl. other regions)	72.6 billion tonnes	171 million tonnes	20,891

Sources: Adapted from DEBRIV (2018) and STATISTA (2018) phase out. Nevertheless, it is commonly accepted that having a large lignite operation in ones' neighbourhood boosts demand for other products and services in the region so that a meta-analysis of 4 studies does conclude that for each direct job in the lignite industry, at least one (regionally up to 2) other jobs are dependent (Öko-Institut, 2017b).

Another feature of these regions is the somewhat inflexible labour market and the advanced age of many of the coal workers. For instance, lignite mining is largely a business for men of 46 years and older (Öko-Institut, 2017b), while recent research in Poland suggests that coal miners made redundant in the mining sector cannot simply switch to other job sectors (such as renewable energies for example) due to different skills needed amongst other factors (Baran et al., 2018). So while the economic importance for coal in certain German regions might be exaggerated, it is certainly not a non-negligible factor.

4.3 The Energy Sector Perspective

Unlike in the German economy overall, the role of coal in the German power sector is still strong and, worse from a climate perspective, remarkably stable. While hard coal is slowly to be phased out, lignite as a share of total electricity production only fell from 25% in 2000 to 22.5% in 2017 (AG Energiebilanzen, 2018). In the same year, coal (lignite and hard coal) accounted for a total of 36.6% of German electricity production and 46.25 GW of installed capacity, down by only 2.4 GW compared to 2002 (Fraunhofer ISE, 2019). In 2016, when the share was still 40% because of the more prominent role of hard coal, this accounted for the release of around 350 million tonnes of CO_2 into the atmosphere (Öko-Institut, 2017b), slightly more than the Spanish economy as a whole (Eurostat, 2018).

There are several reasons for such dominance in the German energy sector. As described above, electricity from coal is relatively cheap to produce. This is all the more so since coal power plants are admittedly captured by the EU Emissions Trading System (EU ETS)—a cap and trade systems which makes power plants pay for exceeding emissions by acquiring tradeable allowances for each tonne of CO_2 emitted—but at an allowance price of around €6 between 2013 and the end 2017[4] means that coal power has remained highly competitive. This absence of a high enough carbon price also contributes to a counter-productive effect of the increasing share of renewable energies which lowers the price for electricity on wholesale markets, thus crowding out gas

[4] Allowance prices can be found at the EEX website.

power plants instead of more polluting coal plants because of the merit order effect, i.e. the shift of the demand clearing price below what is economically attractive for more expensive gas (Sensfuß et al., 2008). Flaws in the current market design, still based on centralised, inflexible fossil fuel-based electricity production, of German and European power markets add to this effect. In the event of negative spot prices in times when more electricity is produced than needed, coal power plants find it more economic to keep on running since coal and pollution is cheap and ramping up and down plant capacity costly (Hildmann et al., 2015). This explains why coal remains popular with power plant owners and German emissions therefore remain high.

The importance of the fossil fuel coal because of socio-cultural and economic historic developments is, however, just half of the story. In contributing to the stability of the socio-technical regime of centralised, top-down fossil fuel-based electricity generation, many actors involved in the coal value chain have a natural interest in the prevalence of the regime because their business models depend on it. Therefore, the role of coal in Germany cannot be properly understood without having a look at who those regime actors are.

5 German Regime Actors: Ambivalent Government, Slow Reacting Utilities

From a policy perspective, it is interesting to note that German policy makers somehow play an ambiguous role in the German energy transition both as regime challenging and regime stabilising forces. When doing so, they wield significant power to mobilise all five type of resources (human, mental, artefactual, monetary and natural) (Avelino and Rotmans, 2009). On the one hand, the German energy transition is a visionary concept which targets a complete overhaul of how Germany produces, distributes and consumes energy, close to what literature calls a stretch-and-transform pathway where few stones are left unturned (Lauber and Jacobsson, 2016). On the other hand, German policy makers, while broadly supporting the energy transition's objective across party lines (ARD, 2017), have oscillated between being at times supportive of transformation and renewables and at times more dismissive (Lauber and Jacobsson, 2016). Indeed, on the European level for instance, Germany has been accused of opposing more ambitious climate action (Stam, 2018). However, this might be considered a quite comprehensible strategy since policy makers are often negotiating between the interests and demands of the niche and the interests and demands of the regime level. It is indeed the role of other regime actors like German utilities who seem to wield a disproportional influence on energy policy.

Like policy makers, the big four utilities wield significant power thanks to their capacity to mobilise resources. Their market dominance allows them to mobilise artefactual resources such as assets as well as money. According to the German Grid Agency's annual report (*Bundesnetzagentur*), the so called big 4 German utilities (RWE, E.ON, Vattenfall and EnBW) had a combined market share of 72.1% of the German electricity market (i.e. power sold on markets) in 2016 (down from 76.1% in 2015), with combined revenues of about €115 billion.[5] It is worth noting that in recent years, those utilities have responded to market pressure (Kungl, 2015) and underwent some significant restructuring, particularly in the year 2016. That year, E.ON transferred its fossil fuel assets to a new subsidiary, *Uniper*, while RWE chose to bundle its renewables capacity under the new subsidiary *Innogy*. Similarly, Vattenfall decided to sell all of its lignite assets in Germany to the Czech company EPH. Later, in March 2018, E.ON and RWE announced their plans for E.ON to acquire *Innogy* from RWE. But despite such restructuring efforts, it is worth emphasising that those four companies are still quite fossil fuel intensive and have not yet fully embraced the energy transition as Table 12.3 shows.

Although direct comparisons are made difficult by the recent restructuring activities, several observations can be made. First, the big four remain heavily fossil fuel based and coal still plays a core role in these companies' business model, which results in them having a natural interest in the stability of the fossil fuel-based power regime. Second, although they increased their investment in renewable energies, with the exception of EnBW, analysed companies are likely not embracing these new technologies as swiftly as they could thus benefiting less from niche technologies slowly transforming (and eventually replacing) the regime. Third, the large utilities have shed some significant amount of employment during the past couple of years, which lends them credibility when mobilising support against the German energy transition and a coal phase out by claiming that a thread to their regime dependent business model would endanger even more job losses. In that vein, they are both able to mobilise human resources—84,000 jobs are a non-negligible pressure tool—as well as mental resources in the form of information, ideology and framing.

These framing activities, either publicly via media channels or behind closed doors to politicians and decision makers via lobbying activities are not to be underestimated. Indeed, studies have shown that the big four, thanks to their dominant market position, are particularly well positioned and sometimes enjoy privileged access to policy makers (Sühlsen and Hisschemöller, 2014). It is true that renewable producers and their interest groups have

[5] Source: company reports; revenues for all operations (German and global).

Table 12.3 Fossil fuel intensity of German 'Big 4' utilities

2012				2017		
Utility	People Employed	Installed power capacity in Germany (coal share parenthesis)	Share of renewables capacity	People Employed	Installed power capacity in Germany (coal in parenthesis)	Installed RES capacity[a] (share in percentages in parenthesis)
RWE	71,419	29.8 GW (60%)	~1% (8% incl. hydro)	35,344[b]	25.5 GW (56%)	about 1 GW or (4%)
Vattenfall	17,729	14.6 GW (61%)	<1% (excl. hydro)	6,800	8.2 GW (34%)	0.6 GW[c] (7.6%)
EnBW	19,998	13.4 GW (37%)	2.5% (18% incl. hydro)	21,352	13.1 GW (33%)	3.3 GW (1 GW excl. hydro) (7.8% excl. hydro)
E.ON	31,548	16.5 GW (39%)	1.2% (10% incl. hydro)	Uniper DE: 4,550; E.ON : 16,138	10.5 GW (43%)	522 MW (5%)
Total	*140,694*	*74.3 GW (51%)*	*~1.4% (excl. hydro)*	*84,184*	*57.3 GW (~42%)*	*~6% (excl. hydro)*

Source: Annual Reports 2012 and 2017 of mentioned companies

[a]RES share for RWE is capacity owned by Innogy divided by RWE capacity; RES share for E.ON is Uniper capacity divided by E.ON

[b]Workforce in Germany only, based on Annual Report 2017

[c]Excluding heat power plants

become a force in Germany as well (Sühlsen and Hisschemöller, 2014), however, despite increasing lobbying and influence taking, it may be doubtful whether they enjoy the same capacity to mobilise knowledge or authority as the big four.

This agenda setting power was witnessed first-hand in the first half of 2015. In order to tackle the paradox between rising electricity generated from RES and, at the same time rising emissions, the German Government proposed to levy a surcharge on polluting power stations in order to achieve necessary emission reductions. While this *Klimabeitrag* (climate contribution) was sold as "fuel neutral" it was effectively aimed at coal power stations. Stakeholders discussed several options in the first half of 2015. Some experts lauded the economic efficiency of this levy (DIW Berlin, 2015) while German utilities and mining companies were mobilising against the measure, launching press releases and even some art-like installations (see Bößner [2016] for more detail). Quite creatively, RWE for instance argued in a press release that lignite would "[…] *contribute to climate protection*." (*Braunkohle und Beschäftigte tragen zu Klimaschutz und Versorgungssicherheit bei*) (RWE, 2015), while all four energy companies sent a letter to the then Minister of Economic Affairs (and SPD chairman) Sigmar Gabriel, urging him to rethink the proposal (Bößner, 2016). In July 2015, the government compromised and decided to phase out 2.7 GW of coal power capacity (or 13% of installed capacity) by 2023. Until that date these power plants will be kept as capacity reserve in order to provide electricity in times of urgent need, a solution that was assessed as being less effective and more costly than the levy (Oei et al., 2015). However, besides the utilities, another player was rather active in the mobilisation against the climate contribution, the German trade unions.

6 What Role for German Unions in the Maintenance of Coal Power?

There are three large unions in Germany, united under the *German Trade Union Federation* (Deutscher Gewerkschaftsbund, DGB): The largest, *IG Metall* represents metal workers, the second largest, *Ver.di* represents the service sector while *IG Bergbau, Chemie und Energie* (IG BCE) represents mining, chemical and energy sector workers. According to the DGB, around 4.7 million people are represented by those three unions, out of a total of around 6 million union members in 2017 (DBG, 2018). Even though union density as part of the population in Germany (17%) is below the OECD average of about 24% (OECD, 2018), membership has been constant over the past decade at around those 6 million and even increased compared to 1999 (DBG, 2018). Moreover, German unions are well connected and organised. According to Greef (2014), unionisation is particularly elevated in the sectors of energy, mining, waste and water where almost 40% of all businesses above five employees have a so called *Betriebsrat* or a workers representation (Greef, 2014). This is clearly an asset when mobilising human resources and making their arguments heard. But German unions do not only possess conduits to business stakeholders and SMEs but also to the German policy environment, particularly to the SPD party which indeed has its roots in the labour movement (see above).

While literature points out that the relationship with the SPD changed throughout the years from a closely knit to a more loose and conflictual one (Schroeder, 2008), people at the higher union governance level are still enjoying privileged access. For instance, all of IG Metall's three chairmen (women have yet to climb to the top level) in the past decade were members of the SPD with Berthold Huber, chairman until 2013, having said to also have close personal ties with chancellor Angela Merkel (Fried, 2010). The IG BCE is also well connected to the social democrats but further boasts ties to German mining and energy companies. Former chairman Hubertus Schmoldt sat on the board of E.ON while current chairman Michael Vassiliadis is on the board of the RAG Stiftung, a foundation tasked with winding down hard coal operations in Germany, close to the mining company RAG AG (RAG Stiftung, 2017). While this double-function might astound non-European readers, it is worth mentioning that in the German model of *Sozialpartnerschaft* (social partnership)—or the collective negotiation of employment conditions and remuneration between employers' representatives and unions—it is not uncommon to have union leaders sit on company boards. However, being close to both mining, energy and electricity companies and the political landscape does suggest a certain level of influence and mobilisation power of particularly mental and human resources, assets which are regularly used to slow down the German energy transition and the tackling of the coal problem.

While two of the three largest unions overall support the Energiewende—*IG Metall* is relatively progressive on energy transition matters, supporting the energy transition and the nuclear phase out (IG Metall, 2015) while *Ver.di*'s press service stated in April 2015 that they would support the energy transition "*without compromises*" (*ohne Abstriche*) (Ver.di, 2015)—IG BCE (2018) has a more complex relationship when it comes to transforming the German energy system. The union often puts forward the argument that the transition was too costly and therefore in need of a reboot (*Neustart*). IG BCE was also instrumental in torpedoing the German government's climate levy proposal (Bößner, 2016). As a culmination of IG BCE's efforts, 15,000 people demonstrated in Berlin against the measure and for the continuous exploitation of lignite (DPA, 2015). While Ver.di and IG Metall were largely absent during the debate, IG BCE (2015a) released press releases warning of the 'social blackout' of entire regions (*sozialer blackout ganzer Regionen*) while chair Michael Vassiliadis spoke of the "*sweet poison of climate populism*" (*süßes Gift des Klimapopulismus*) when referring to the government's proposal (IG BCE, 2015b). In the end, it was the IG BCE's proposition of having a capacity reserve instead of the levy which largely prevailed despite being economically and environmentally less optimal. As analysis has shown, they were largely successful in framing the measure to make coal pay for its pollution as a policy which would endanger jobs and economic prosperity (Bößner, 2016).

Judging from those past experiences, German unions play a somewhat ambiguous role in the German energy transition and in the country's continuous love affair with coal. While some unions seem to be rather progressive (or at least not actively hindering the transition), some union players such as IG BCE seem to be more reluctant to give in to niche pressure and present themselves as formidable actors of the regime. Unfortunately, this reluctance to accept the changes that the energy transition—and indeed the international Paris Agreement—will make necessary, namely to phase out coal sooner rather than later, has not changed in recent years.

7 Recent Developments: *Klimafahrplan* and the 'Coal Commission', a Window of Opportunity?

In response to developments in the international climate governance sphere for which the adoption of the landmark Paris Agreement is the most prominent example, as well as due to growing scientific consensus that coal has to be phased out soon if humanity is to stabilise the climate (IPCC, 2018), the German Government adopted its new, updated climate strategy (*Klimaschutzplan*) for 2050 in 2016 (Deutsche Bundesregierung, 2016). This plan came about after a long battel between different interest groups, pitting environmental minister Barbara Hendricks (SPD) against her party colleague Sigmar Gabriel who endorsed the standpoint of German utilities and IG BCE who lobbied against the text containing references to a coal phase out (DPA, 2016a, b). In the end a compromise prevailed.

While a coal phase out has not been written into the plan directly, the interim emissions target for the energy sector of 175–183 $MtCO_2e$ by 2030 will likely not be able to be met if coal is still part of the German electricity mix. More remarkable, from a governance perspective, is the implementation of a commission for 'growth, structural transformation and regional development' (*Wachstum, Strukturwandel und Regionalentwicklung*), more often referred to by the name—*Kohlekommission*—indicating its foremost purpose: the orderly phase out of coal. The thirty-one member seat on the commission, comprising representatives from industry, politics, NGOs, research and unions (Kern and Meier, 2018), deliberated a consensus based report on how coal could be phased out in coal intensive regions.

This commission is therefore a window of opportunity which might have opened in the German political landscape. International and national pressure is mounting on Germany to tackle its emissions, the German energy transition is well advanced and the regime actors have recently reacted to niche pressure by either selling their coal assets or splitting their companies into fossil fuel based and renewable based business models. However, when it comes to aspects of power and agency, regime forces still put up a fight.

For instance, Michael Vassilidis of IG BCE is a member of the commission as are other stakeholders who have either in the past supported the lignite industry such as former minister-president of the *Land* Brandenburg Matthias Platzeck (Kern and Meier, 2018) or have been critical of the energy transition such as Dieter Kempf, chairman of Federation of German Industries (BDI) (DPA, 2018). Unsurprisingly, negotiations proved to be difficult. A leaked alleged compromise aiming to phase out coal between 2035 and 2038 prompted opposition from RWE and IG BCE (Reuters, 2018) and the arguments made by regime players such as RWE or IG BCE against a timely coal phase out are quite familiar from those used in 2015: fear of decreasing security of electricity supply (Frese, 2018), job losses (Bröcker and Hoenig, 2018) and loss of competitiveness for the German industry due to higher electricity prices (Stratmann, 2018).

It is this power to frame the debate which proves to be a fundamental obstacle to the German energy transition in general and to the role of coal in Germany. This framing power seems to prevail despite the fact that research suggests that many of the arguments against a coal phase out cannot be sustained.

For instance, studies have shown that security of electricity supply would remain assured even if coal and nuclear were to be phased out completely (Agora Energiewende, 2017). Similarly, German grid stability remains high despite a high share of renewables (Kunz et al., 2013) and provided the electricity market design is adapted with the European context (Newbery, 2017; Ahrens, 2017) the German grid will remain stable with a high renewable share thus making the phase out of coal technically possible.

In the same vein, and despite higher electricity prices in the past, the overall competitiveness of the German industry, despite a lack of comprehensive data and some sectors indeed suffering, seems to be assured given the industry's efficiency gains over time (Germeshausen and Löschel, 2015). And as we have seen, jobs in renewables largely eclipse jobs in the coal sector. However, detailed macro-economic studies on the impacts of a coal phase out are still too few to offer a complete picture (Wehnert et al., 2017). Moreover, past experiences of the energy transition show that there are some negative effects such as regressive distribution of wealth (Hecking et al., 2016).

Nevertheless, it flows from these observations that, from a technical and economic perspective, a coal phase out is possible and indeed needed in light of the recent IPPC report that the world has just 12 years to limit a climate catastrophe (IPCC, 2018). Against this backdrop, the coal commission did manage to agree on a final report which suggested a complete coal phase out by 2038 (Tillich et al., 2019). However, given the social consequences in coal intensive regions and the fact that regime actors have still not fully embraced the energy transition nor a coal phase out (thus still fighting for the survival of their preferred regime), the devil will be in the detail on how this phase out will be achieved. Provided political will prevails, the recommendations of the final report have to be translated into concrete laws, the design of which might be disputed along the way. Indeed, the recommendations of the report are already being criticised by some experts (Evans, 2019; Wetzel, 2019) and might be insufficient given the German government's 2030 emissions reduction target in the energy sector according to its *Klimaschutzplan*.

Be that as it may, a coal phase out is slowly under way in Germany and several elements might help to render the transition more acceptable to key regime stakeholders who, as we have seen, are still able to put up a fight and to use their power to stall or even derail policies catering to a coal phase out.

8 Strategies for the Future[6]

First, it is useful to be reminded that niche technologies such as renewable energies are increasingly a viable alternative to the German fossil fuel-based regime. As of 2016, more than 321,000 people were working in the renewables industry in Germany, the sector generating more than €40 billion of revenue (EurObserv'ER, 2017) while the grid remains stable. This success

[6] This chapter was written and submitted in 2018 while the coal commission's recommendations have only been available since the end of January 2019. Therefore, recommendations given in this chapter are not based on the recommendations of the coal commission, but on academic and grey literature. However, it is safe to assume that significant overlaps in this chapter's recommendations and those of the coal commission might be found. Since this chapter mainly investigates the power and agency of German coal actors and not how exactly and at what cost a coal phase out might be achieved, the absence of a careful analysis of the coal commission report is justified.

story also means tax revenues, especially for local governments; a 2013 study found that most of the added value of renewable energies is achieved (and remains) at the sub-national level (Aretz et al., 2013). It is only if niche technologies are able to provide a viable alternative, that phasing out one energy sources such as coal makes sense from an economic and energy security perspective.

However, during these transformations, not everyone will benefit equally. For instance, renewable energy support in Germany has a regressive element to it, burdening low-income household disproportionately (Diekmann et al., 2016). Similarly, jobs lost in coal mining regions due to pit and plant closures are surely to be felt in regions where coal is a large employment factor. It is therefore critical to not only to share the burden fairly and proportionally, but also to share the benefits of any transitions in an equitable manner.

For coal regions, this means having specific strategies in place on how to dampen the impact of a coal phase out and on how to revitalise coal regions culturally, economically and environmentally. However, this support needs to put people and regions first and not transform into pay-outs for mining companies or utilities. Several options exist although solutions have to be adopted to each specific regional case since one size fits all solutions are bound to fail.

Long term planning and visibility is one element as the better a coal phase-out and its consequences are anticipated, the better the results are in those regions because all stakeholders can plan appropriately (Caldecott et al., 2017). Moreover, Germany already has had some experience with the orderly phase out of hard coal and its mechanisms implemented could serve as inspiration for a lignite phase out (see Bößner 2016 for a description of the hard coal phase out).

Another element would be to invest in human capital and provide coal workers with the necessary education, vocational training and updated skills in order to find employment in other sectors more easily despite the fact that higher regional unemployment might persist for a while as evidence in UK coal regions suggest (Fothergill, 2017).

When it comes to revitalising coal mining regions, success stories from the restructuring of the steel industry in the Saarland could provide some elements of inspiration for coal regions. There, investment in research and development, the creation of research centres and universities as well as the support of SMEs helped by EU structural funding led to the emergence to regional technology and innovation clusters (Alves Dias et al., 2018) although, in practice, barriers like old networks and lock-in generated by the old industry and its practices have to be overcome first (Campbell and Coenen, 2017).

Another pathway worth exploring is the case of the Zollverein mine in Essen, which is now an open air museum and UNESCO world heritage site, visited by 1.5 million tourists a year (Bryce, 2017). Other options include using the space of former coal mines as host sites for large scale renewables installations (Alves Dias et al., 2018) or the mines itself as pump-storage sites for grid balancing services (Pujades et al., 2016; UPSW, 2018).

Of course, using these strategies to their fullest potential will depend on the details of each strategy and policy mix adopted. Moreover, it is clear from the behaviour of German regime actors that they will not go quietly. It is therefore of utmost importance to ring in regional phase outs by encouraging a multi-stakeholder dialogue. Germany sets a good example with its coal commission. Only if all stakeholders' voices are heard and the pathway is imagined, debated and designed collaboratively, the needed transition from dirty to clean energy in coal regions will be a success.

References

AG Energiebilanzen. 2018. Bruttostromerzeugung in Deutschland Ab 1990 Nach Energietraegern. AG Energiebilanzen. https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20171221_brd_stromerzeugung1990-2017.pdf.

Agora Energiewende. 2017. Kohleausstieg, Stromimporte Und -Exporte Sowie Versorgungssicherheit. Kurz-Analyse. Agora Energiewende. https://www.agora-energiewende.de/fileadmin2/Projekte/2015/Kohlekonsens/Agora_Kurzanalyse-Kohleausstieg-und-Versorgungssicherheit_10112017.pdf.

Ahrens, C.D. 2017. Transition to Very High Share of Renewables in Germany. *CSEE Journal of Power and Energy Systems* 3(1): 17–25. https://doi.org/10.17775/CSEEJPES.2017.0004.

Alves Dias, P. et al. 2018. EU Coal Regions: Opportunities and Challenges Ahead. EUR—Scientific and Technical Research Reports. Publications Office of the European Union. JRC112593. https://doi.org/10.2760/668092 (print).

ARD. 2017. Wie die Parteien die Energiewende gestalten wollen. *tagesschau.de*. https://www.tagesschau.de/inland/btw17/programmvergleich/programmvergleich-energie-101.html.

Arendt, H. 1995. *Macht Und Gewalt*. München: Piper Verlag GmbH.

Aretz, A., Heinbach, K., Hirschl, B. and Schröder, A. 2013. Wertschöpfungs-und Beschäftigungseffekte durch den Ausbau Erneuerbarer Energien. Institut für ökologische Wirtschaftsforschung (IÖW). https://www.ioew.de/fileadmin/user_upload/BILDER_und_Downloaddateien/Publikationen/2013/20130902_Greenpeace-Studie-Wertschoepfung.pdf.

Avelino, F. and Rotmans, J. 2009. Power in Transition: An Interdisciplinary Framework to Study Power in Relation to Structural Change. *European Journal of Social Theory* 12(4): 543–69. https://doi.org/10.1177/1368431009349830.

Baran, J., Lewandowski, P., Szpor, A. and Witajewski, J. 2018. Coal Transition in Poland. Options for a Fair and Feasible Transition for the Polish Coal Sector. *IBS*. https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/20180609_ReportCOAL_Poland-.pdf.

Baun, M.J. 1995. The Maastricht Treaty as High Politics: Germany, France, and European Integration. *Political Science Quarterly* 110(4): 605–624. https://doi.org/10.2307/2151886.

Bell, S.E. and York, R. 2010. Community Economic Identity: The Coal Industry and Ideology Construction in West Virginia. *Rural Sociology* 75(1): 111–143. https://doi.org/10.1111/j.1549-0831.2009.00004.x.

Bößner, S. 2016. *Turning Energy Around: Coal and the German Energiewende*. Stockholm Environment Institute. https://www.sei.org/mediamanager/documents/Publications/Climate/SEI-DB-2016-Energiewende-and-coal.pdf.

Bröcker, M. and Hoenig, A. 2018. Interview mit RWE-Chef Rolf Martin Schmitz: 'Ein Kohleausstieg bis 2030 ist nicht zu schaffen'. *RP Online*. https://rp-online.de/wirtschaft/unternehmen/rwe-chef-rolf-martin-schmitz-kohleausstieg-bis-2030-unmoeglich_aid-23553795.

Bryce, E. 2017. Germany's Transition from Coal to Renewable Energy Offers Lessons for the Rest of the World. *Ensia* (blog). https://ensia.com/features/german-transition-coal-renewable-energy/.

Bundesministerium für Wirtschaft und Energie. 2018. Eine Zielarchitektur für die Energiewende: Von politischen Zielen bis zu Einzelmaßnahmen. https://www.bmwi.de/Redaktion/DE/Artikel/Energie/zielarchitektur.html.

Burkitt, I. 2016. Relational Agency: Relational Sociology, Agency and Interaction. *European Journal of Social Theory* 19(3): 322–339. https://doi.org/10.1177/1368431015591426.

Busch, C. and Gimon, E. 2014. Natural Gas versus Coal: Is Natural Gas Better for the Climate? *The Electricity Journal* 27(7): 97–111. https://doi.org/10.1016/j.tej.2014.07.007.

Caldecott, B., Sartor, O. and Spencer, T. 2017. Coal Transitions. High-Level Summary for Decision Makers. *IDDRI*. https://coaltransitions.files.wordpress.com/2016/09/coal_synthesisreport_v04.pdf.

Campbell, S. and Coenen, L. 2017. Transitioning Beyond Coal: Lessons from the Structural Renewal of Europe's Old Industrial Regions. Australian National University. https://coaltransitions.files.wordpress.com/2017/11/australian-coal-transition-industrialization-final.pdf.

Chiesura, A. and de Groot, R. 2003. Critical Natural Capital: A Socio-Cultural Perspective. *Ecological Economics*, Identifying Critical Natural Capital 44(2): 219–231. https://doi.org/10.1016/S0921-8009(02)00275-6.

DBG. 2018. DGB-Mitgliederzahlen 2010–2017. Deutscher Gewerkschaftsbund. http://www.dgb.de/uber-uns/dgb-heute/mitgliederzahlen/2010.

DEBRIV. 2018. *Braunkohle in Deutschland. Daten Und Fakten 2017*. Bundesverband Braunkohle. https://www.braunkohle.de/4-0-Zahlen-und-Fakten.html.

Deutsche Bundesregierung. 2016. *Klimaschutzplan 2050—Klimaschutzpolitische Grundsätze und Ziele der Bundesregierung*. Berlin: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit.

Diekmann, J., Breitschopf, B. and Lehr, U. 2016. Social Impacts of Renewable Energy in Germany: Size, History and Alleviation. *GWS*. https://www.gws-os.com/discussionpapers/gws-paper16-7.pdf.

DIW Berlin. 2015. DIW Berlin: Klimabeitrag Kann CO2-Emissionen Im Stromsektor Effektiv Und Kostenguenstig Senken—Alternative Votschlaege Ieffektiv Und Teuer. DIW Berlin. http://www.claudiakemfert.de/wp-content/uploads/2016/03/Kurzfassung_Studie.pdf.

DPA. 2015. Kohle-Streit: Tausende demonstrieren für und gegen Braunkohle. *ZEIT Online*, April 25, 2015. https://www.zeit.de/wirtschaft/2015-04/sigmar-gabriel-braunkohle-demos.

DPA. 2016a. Klimaschutzplan 2050: Gabriel stoppt Klimaplan und brüskiert Hendricks. *Handelsblatt*, August 11, Online Edition. https://www.handelsblatt.com/politik/deutschland/klimaschutzplan-2050-gabriel-stoppt-klimaplan-und-brueskiert-hendricks/14814170.html.

DPA. 2016b. Regierungskonzept: Kohlekompromiss Ebnet Einigung Auf Klimaplan. *Spiegel Online*, November 11, sec. Wissenschaft. http://www.spiegel.de/wissenschaft/natur/klimaschutzplan-2050-regierung-einigt-sich-nach-streit-a-1120863.html.

DPA. 2018. Kosten Der Energiewende: BDI-Chef Warnt Vor Produktionsverlagerung Ins Ausland. *Spiegel Online*, January 8, sec. Wirtschaft. http://www.spiegel.de/wirtschaft/unternehmen/energiewende-bdi-chef-warnt-vor-abwanderung-ins-ausland-a-1186678.html.

EIA. 2018. How Much Carbon Dioxide Is Produced When Different Fuels Are Burned? US Energy Information Administration. https://www.eia.gov/tools/faqs/faq.php?id=73&t=11.

EurObserv'ER. 2017. *The State of Renewable Energies in Europe*, Edition 2017. Paris: Observ'ER. https://www.eurobserv-er.org/17th-annual-overview-barometer/.

Eurostat. 2018. Greenhouse Gas Emissions by Source Sector, 12 September 2018. http://appsso.eurostat.ec.europa.eu/nui/show.do?lang=en&dataset=env_air_gge.

Evans, S. 2019. How Far Would Germany's 2038 Coal Phaseout Breach Paris Climate Goals? *Carbon Brief*, January 29. https://www.carbonbrief.org/analysis-how-far-would-germanys-2038-coal-phaseout-breach-paris-climate-goals.

Fothergill, S. 2017. Coal Transition in the United Kingdom. Sheffield Hallam University. https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/201706-iddri-climatestrategies-coal_uk.pdf.

Frantal, B. 2016. Living on Coal: Mined-out Identity, Community Displacement and Forming of Anti-Coal Resistance in the Most Region, Czech Republic. *Resources Policy* 49: 385–393. https://doi.org/10.1016/j.resourpol.2016.07.011.

Fraunhofer ISE. 2016. Annual Electricity Spot Market Prices in Germany, 11 May 2016. https://www.energy-charts.de/price_avg.htm?year=2011&price=nominal&period=annual.

Fraunhofer ISE. 2019. Net Installed Electricity Generation Capacity in Germany, 31 January 2019. https://www.energy-charts.de/power_inst.htm.

Frese, A. 2018. Wenn wir die Klimafrage überdrehen, wird es gefährlich. *Der Tagesspiegel Online*, October 4. https://www.tagesspiegel.de/wirtschaft/gewerkschaftsboss-michael-vassiliadis-wenn-wir-die-klimafrage-ueberdrehen-wird-es-gefaehrlich/23145988.html.

Fried, N. 2010. Liebe geht durch den Magen. *Sueddeutsche Zeitung*, 2010, Online Edition, sec. wirtschaft. https://www.sueddeutsche.de/wirtschaft/ig-metall-chef-huber-liebe-geht-durch-den-magen-1.16537.

Fröhlich, A. 2015. Sozialer Blackout. *Der Tagesspiegel Online*, April 24. https://www.tagesspiegel.de/politik/kohle-in-der-lausitz-sozialer-blackout/11687284.html.

Geels, F. 2002. Technological Transitions as Evolutionary Reconfiguration Processes—A Multilevel Perspective and a Case Study. *Research Policy* 31(8–9): 1257–1274.

Geels, F.W. 2011. The Multi-Level Perspective on Sustainability Transitions: Responses to Seven Criticisms. *Environmental Innovation and Societal Transitions*. In Press, Accepted Manuscript. http://www.sciencedirect.com/science/article/B6KKF-52890RW-2/2/b84768abfe3e2d05f2830d753db4ac84.

Geels, F.W. 2014. Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society* 31(5): 21–40. https://doi.org/10.1177/0263276414531627.

Geels, F. and Schot, J. 2007. Typology of Sociotechnical Transition Pathways. *Research Policy* 36: 399–417.

Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M. and Wassermann, S. 2016. The Enactment of Socio-Technical Transition Pathways: A Reformulated Typology and a Comparative Multi-Level Analysis of the German and UK Low-Carbon Electricity Transitions (1990–2014). *Research Policy* 45(4): 896–913. https://doi.org/10.1016/j.respol.2016.01.015.

Gerlach, F. and Ziegler, A. 2015. Konturen Einer Proaktiven Industriepolitik—Das Beispiel Deutschland. *WSI Mitteilungen* 68(7): 526–533.

Germeshausen, R. and Löschel, A. 2015. Energiestückkosten als Indikator für Wettbewerbsfähigkeit. *Wirtschaftsdienst—Zeitschrift für Wirtschaftspolitik* 95(1): 46–50.

Giddens, A. 1984. *The Constitution of Society*. Berkeley: University of California Press. https://www.ucpress.edu/book/9780520057289/the-constitution-of-society.

Greef, S. 2014. Gewerkschaften im Spiegel von Zahlen, Daten und Fakten. In: Schroeder, W. (Ed.) *Handbuch Gewerkschaften in Deutschland*. Wiesbaden: Springer Fachmedien Wiesbaden, pp. 657–755. https://doi.org/10.1007/978-3-531-19496-7_25.

Grubb, M., McDowall, W. and Drummond, P. 2017. On Order and Complexity in Innovations Systems: Conceptual Frameworks for Policy Mixes in Sustainability Transitions. *Energy Research & Social Science: Policy Mixes for Energy Transitions* 33(November): 21–34. https://doi.org/10.1016/j.erss.2017.09.016.

Hecking, H., Kruse, J., Paschmann, M., Polisadov, A. and Wildgrube, T. 2016. *Ökonomische Effekte Eines Deutschen Kohleausstiegs Auf Den Strommarkt in Deutschland Und Der EU*. Cologne: EWI. https://www.ewi.research-scenarios.de/cms/wp-content/uploads/2016/05/ewi_ers_oekonomische_effekte_deutscher_kohleausstieg.pdf.

Heinrich Böll Stiftung. 2018. Energieatlas 2018. Daten Und Fakten Ueber Die Erneuerbaren in Europa. Heinrich Böll Stiftung. https://www.boell.de/sites/default/files/energieatlas2018.pdf.

Hildmann, M., Ulbig, A. and Andersson, G. 2015. Revisiting the Merit-Order Effect of Renewable Energy Sources. In: *2015 IEEE Power & Energy Society General Meeting*, July, 1–1. https://doi.org/10.1109/PESGM.2015.7286477.

Hobsbawm, E. 1987. *The Age of Empire. 1875–1914*. London: Weidenfeld and Nicolson.

Hobsbawm, E. 2012. *The Age of Capital. 1848–1875*. London: Abacus.

Hockenos, P. 2017. Germany Is a Coal-Burning, Gas-Guzzling Climate Change Hypocrite. *Foreign Policy* (blog), November. https://foreignpolicy.com/2017/11/13/germany-is-a-coal-burning-gas-guzzling-climate-change-hypocrite/.

IG BCE. 2015a. Gegen den sozialen Blackout ganzer Regionen, 14 April 2015. https://www.igbce.de/aufruf-demo-berlin-energie-25-4-2015/103140.

IG BCE. 2015b. Vassiliadis: Die Politik riskiert den sozialen Blackout ganzer Regionen, 25 March 2015. https://www.igbce.de/themen/energie/xix-16-fehlentscheidung-energiepolitik/101884.

IG BCE. 2018. Die Energiewende braucht einen Neustart, 16 August 2018. https://www.igbce.de/themen/energie/fakten-und-stimmen-zur-energiewende-1/171428.

IG Metall. 2015. So steht die IG Metall zur Energiewende, 1 July 2015. https://www.igmetall.de/so-steht-die-ig-metall-zur-energiewende-16635.htm.

Ioakimidis, C., Koukouzas, N., Chatzimichali, A., Casimiro, S. and Itskos, G. 2011. Assessment for Carbon Capture and Storage Opportunities: Greek Case Study. In: Pistikopoulos, E.N., Georgiadis, M.C. and Kokossis, A.C. (Eds.) *Computer Aided Chemical Engineering. 21st European Symposium on Computer Aided Process Engineering* 29: 1939–1943. https://doi.org/10.1016/B978-0-444-54298-4.50166-5.

IPCC. 2018. Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Summary for Policy Makers, IPCC, Incheon, Republic of Korea.

Jones, D., Huscher, J., Mylyvirta, L., Gierens, R., Fliskowa, J., Gutmann, K., Urbaniak, D. and Azau, S. 2016. Europe's Dark Could. How Coal-Burning Countries Are Making Their Neighbours Sick. CAN Europe and WWF Europe. http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Europes_dark_cloud_report_2016.pdf.

Judt, T. 2005. *Postwar*. New York: The Penguin Press.
Kemfert, C., Opitz, P., Traber, T. and Handrich, L. 2015. Deep Decarbonization in Germany: A Macro-Analysis of Economic and Political Challenges of the 'Energiewende' (Energy Transition). DIW Berlin: Politikberatung kompakt. DIW Berlin, German Institute for Economic Research. https://econpapers.repec.org/bookchap/diwdiwpok/pbk93.htm.
Kern, V. and Meier, F. 2018. Das sind die Mitglieder der Kohlekommission. klimareporter 2018. http://www.klimareporter.de/deutschland/das-sind-die-mitglieder-der-kohlekommission.
Kost, C., Shammugam, S., Jülch, V., Nguyen, H.T. and Schlegl, T. 2018. Stromgestehungskosten Erneuerbare Energien. Maerz 2018. Fraunhofer ISE. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/DE2018_ISE_Studie_Stromgestehungskosten_Erneuerbare_Energien.pdf.
Krewitt, W. and Nitsch, J. 2003. The German Renewable Energy Sources Act—An Investment into the Future Pays off Already Today. *Renewable Energy* 28(4): 533–542. https://doi.org/10.1016/S0960-1481(02)00064-2.
Kungl, G. 2015. Stewards or Sticklers for Change? Incumbent Energy Providers and the Politics of the German Energy Transition. *Energy Research & Social Science* 8(July): 13–23. https://doi.org/10.1016/j.erss.2015.04.009.
Kunz, F., Gerbaulet, C. and von Hirschhausen, C. 2013. Mittelfristige Strombedarfsdeckung durch Kraftwerke und Netze nicht gefährdet. *DIW Wochenbericht* 48: 14.
Kuzemko, C., Lockwood, M., Mitchell, C. and Hoggett, R. 2016. Governing for Sustainable Energy System Change: Politics, Contexts and Contingency. *Energy Research & Social Science* 12(February): 96–105. https://doi.org/10.1016/j.erss.2015.12.022.
Lauber, V. and Jacobsson, S. 2016. The Politics and Economics of Constructing, Contesting and Restricting Socio-Political Space for Renewables—The German Renewable Energy Act. *Environmental Innovation and Societal Transitions* 18(March): 147–163. https://doi.org/10.1016/j.eist.2015.06.005.
Marcacci, S. 2018. Uneconomic Coal Could Be Squeezed Out of European Union Power Markets by 2030. *Forbes*. https://www.forbes.com/sites/energyinnovation/2018/06/11/uneconomic-coal-could-be-squeezed-out-of-european-union-power-markets-by-2030/.
Meadowcroft, J. 2009. What about the Politics? Sustainable Development, Transition Management, and Long Term Energy Transitions. *Policy Sciences* 42(4): 323–340.
Newbery, D.M. 2017. Designing an Electricity Wholesale Market to Accommodate Significant Renewables Penetration: Lessons from Britain. Energy Policy Research Group Cambridge. https://www.eprg.group.cam.ac.uk/wp-content/uploads/2018/01/1719-Text.pdf.
OECD.Stat. 2018. *Trade Union Density*. OECD. https://stats.oecd.org/Index.aspx?DataSetCode=TUD#.

Oei, P-Y., Gerbaulet, C., Kemfert, C., Kunz, F., Reitz, F., Von Hirschhausen, C. and Deutsches Institut für Wirtschaftsforschung (DIW Berlin). 2015. *Effektive CO2-Minderung im Stromsektor: Klima-, Preis-und Beschäftigungseffekte des Klimabeitrags und alternativer Instrumente*. Berlin: Deutsches Institut für Wirtschaftsforschung. http://nbn-resolving.de/urn:nbn:de:0084-diwkompakt_2015-0985.

Öko-Institut. 2017a. Die Deutsche Braunkohlewirtschaft. Historische Entwicklungen, Ressourcen, Technik, Wirtschaftliche Strukturen Und Umweltauswirkungen. Berlin: Agora Energiwende.

Öko-Institut. 2017b. Die Deutsche Braunkohlewirtschaft. Historische Entwicklungen, Ressourcen, Technik, Wirtschaftliche Strukturen Und Umweltauswirkungen. Berlin: Agora Energiwende. https://www.agora-energiewende.de/fileadmin2/Projekte/2017/Deutsche_Braunkohlenwirtschaft/Agora_Die-deutsche-Braunkohlenwirtschaft_WEB.pdf.

Pujades, E., Willems, T., Bodeux, S., Orban, P. and Dassargues, A. 2016. Underground Pumped Storage Hydroelectricity Using Abandoned Works (Deep Mines or Open Pits) and the Impact on Groundwater Flow. *Hydrogeology Journal* 24(6): 1531–1546. https://doi.org/10.1007/s10040-016-1413-z.

RAG Stiftung. 2017. RAG Stiftung. Jahresbericht 2017. https://www.rag-stiftung.de/fileadmin/user_upload/RAG-Stiftung/Dokumente/geschaeftsberichte/RAG-Stiftung_GB2017_D.pdf.

Raven, R., Kern, F., Smith, A., Jacobsson, S. and Verhees, B. 2016. The Politics of Innovation Spaces for Low-Carbon Energy: Introduction to the Special Issue. *Environmental Innovation and Societal Transitions* 18(March): 101–110. https://doi.org/10.1016/j.eist.2015.06.008.

Reuters. 2018. RWE und Gewerkschaft laufen Sturm gegen Pläne für Kohle-Aus. *Der Tagesspiegel*, September 16. https://www.tagesspiegel.de/wirtschaft/kohleausstieg-rwe-und-gewerkschaft-laufen-sturm-gegen-plaene-fuer-kohle-aus/23073646.html.

Rogge, K.S. and Reichardt, K. 2016. Policy Mixes for Sustainability Transitions: An Extended Concept and Framework for Analysis. *Research Policy* 45(8): 1620–1635. https://doi.org/10.1016/j.respol.2016.04.004.

Rosenow, J., Kern, F. and Rogge, K. 2017. The Need for Comprehensive and Well Targeted Instrument Mixes to Stimulate Energy Transitions: The Case of Energy Efficiency Policy. *Energy Research & Social Science*: *Policy mixes for energy transitions* 33(November): 95–104. https://doi.org/10.1016/j.erss.2017.09.013.

RWE. 2015. Matthias Hartung: Braunkohle und Beschäftigte tragen zu Klimaschutz und Versorgungssicherheit bei. http://www.rwe.com/web/cms/de/2320/rwe-power-ag/pressemitteilungen/pressemitteilungen/?pmid=4013567.

Schot, J. and Geels, F.W. 2008. Strategic Niche Management and Sustainable Innovation Journeys: Theory, Findings, Research Agenda, and Policy. *Technology Analysis & Strategic Management* 20(5): 537–554. https://doi.org/10.1080/09537320802292651.

Schroeder, W. 2008. SPD Und Gewerkschaften: Vom Wandel Einer Priviligierten Partnerschaft. *WSI Mitteilungen* 61(5): 231–237.

Sensfuß, F., Ragwitz, M. and Genoese, M. 2008. The Merit-Order Effect: A Detailed Analysis of the Price Effect of Renewable Electricity Generation on Spot Market Prices in Germany. *Energy Policy* 36(8): 3086–3094. https://doi.org/10.1016/j.enpol.2008.03.035.

Smith, A., Stirling, A. and Berkhout, F. 2005. The Governance of Sustainable Socio-Technical Transitions. *Research Policy* 34(10): 1491–1510. https://doi.org/10.1016/j.respol.2005.07.005.

Smith, A., Voß, J.P. and Grin, J. 2010. Innovation Studies and Sustainability Transitions: The Allure of the Multi-Level Perspective and Its Challenges. *Research Policy* 39(4): 435–448. https://doi.org/10.1016/j.respol.2010.01.023.

Snow, D.A. 2013. Framing and Social Movements. In: *The Wiley-Blackwell Encyclopedia of Social and Political Movements*. American Cancer Society. https://doi.org/10.1002/9780470674871.wbespm434.

Stam, C. 2018. European Commission Abandons Plans to Raise Climate Ambition. *Euractiv.Com* (blog), October 2. https://www.euractiv.com/section/climate-environment/news/european-commission-to-abandon-plans-for-rising-climate-ambition/.

STATISTA. 2018. Fossile Energie: Kohle in Deutschland. Hamburg.

STATISTA. 2019. Turnover of the Mining of Coal and Lignite Industry in Germany from 2008 to 2014 (in Million Euros). https://www.statista.com/statistics/422106/turnover-mining-of-coal-and-lignite-germany/.

Stratmann, K. 2018. Energie: Kohleausstieg kostet die Verbraucher Milliarden—energieintensive Branchen schlagen Alarm. *Handelsblatt*, August 20, Online Edition. https://www.handelsblatt.com/politik/deutschland/energie-kohleausstieg-kostet-die-verbraucher-milliarden-energieintensive-branchen-schlagen-alarm/22931396.html.

Strunz, S. 2014. The German Energy Transition as a Regime Shift. *Ecological Economics* 100(April): 150–158. https://doi.org/10.1016/j.ecolecon.2014.01.019.

Sühlsen, K. and Hisschemöller, M. 2014. Lobbying the 'Energiewende'. Assessing the Effectiveness of Strategies to Promote the Renewable Energy Business in Germany. *Energy Policy* 69(June): 316–325. https://doi.org/10.1016/j.enpol.2014.02.018.

Taylor, R., Sotiris, P., Wanjiru, H., van Vliet, O.P.R. and Lieu, J. 2017. D6.3: Report on Investigating Agency at Firms and Individual Household Levels, Including Method/Model Documentation and Analytical Findings. TRANSrisk Report. TRANSrisk. University of Sussex.

Thucydides and Crawley, R. 1910. *History of the Peloponnesian War*. London: J.M. Dent E.P. Dutton.

Tillich, S., Praetorius, B. and Pofalla, R. 2019. Abschlussbericht Kommission "Wachstum, Strukturwandel Und Beschäftigung". https://www.greenpeace.de/

sites/www.greenpeace.de/files/publications/abschlussbericht_kommission_wachstum_strukturwandel_und_beschaeftigung_beschluss.pdf.

Tveten, Å.G., Bolkesjø, T.F., Martinsen, T. and Hvarnes, H. 2013. Solar Feed-in Tariffs and the Merit Order Effect: A Study of the German Electricity Market. *Energy Policy* 61(October): 761–770. https://doi.org/10.1016/j.enpol.2013.05.060.

Umweltbundesamt. 2015. Daten Und Fakten Zu Braun-Und Steinkohlen. Status Quo Und Perspektiven. Umweltbundesamt.

Umweltbundesamt. 2017. Daten Und Fakten Zu Braun-Und Steinkohlen. Umweltbundesamt.

UPSW. 2018. Konzepte Für Regionale Speicher Regenerativer Energien—Underground Pumped Storage. http://www.upsw.de/index.php/en/.

Van Hook, J.C. 2004. *Rebuilding Germany: The Creation of the Social Market Economy, 1945–1957*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511511936.

Ver.di. 2015. Breiter Konsens für Energiewende erforderlich – ver.di unterstützt BDEW-Appell, 24 April 2015. https://www.verdi.de/presse/pressemitteilungen/++co++1a07d170-ea62-11e4-a2b2-5254008a33df.

Weber, M. 1922. *Wirtschaft Und Gesellschaft. Grundriss Der Verstehenden Soziologie*. Mohr. Vol. 1. Tuebigen.

Wehnert, T., Best, B. and Andreeva, T. 2017. Kohleausstieg—Analyse von aktuellen Diskussionsvorschlägen und Studien. Wuppertal Institut. https://epub.wupperinst.org/frontdoor/deliver/index/docId/6686/file/6686_Kohleausstieg.pdf.

Wetzel, D. 2019. Darum Wird Der Kohle-Kompromiss Noch Richtig Teuer, January 26, 2019. https://www.welt.de/wirtschaft/article187744228/Darum-wird-der-Kohle-Kompromiss-noch-richtig-teuer.html.

World Bank. 2018. Industry (Including Construction), Value Added (% of GDP) | Data. https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=DE-EU.

13

Fossil Fuel Decline and the Rural Economy: The Case of Scotland

Bill Slee

1 Introduction

The production of energy, especially renewable energy, has attracted considerable interest by development economists operating in developing countries but there is an absence of studies of the links between energy production and rural development in developed countries. There are studies of particular technologies and modes of provision and their impacts on rural communities (e.g. Hain et al., 2005; Okkonen, 2008; Munday et al., 2011; Slee, 2015), but no overarching picture of how, over time, different forms of energy exploitation have influenced rural development, although Brassley et al. (2017) have recently undertaken a UK-wide exploration of the uptake of rural electricity. This chapter seeks to remedy that omission with respect to Scotland, taking a long view of both renewable and non-renewable energy developments and their impacts on the Scottish rural economy.

Energy has been a hugely important but largely unrecorded influence on the Scottish rural economy. To explore this, the idea of a socio-technical regime, widely used in the study of transitions towards sustainable energy production (Geels, 2002, 2005; Geels and Schot, 2007; Geels et al., 2018; Hargreaves et al., 2013; Murphy and Smith, 2013) is applied. According to Rip and Kemp (1998): "*a socio-technical regime is the rule-set or grammar embedded in a complex of engineering practices; production process technologies;*

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product characteristics, skills and procedures; ways of handling relevant artefacts and persons; ways of defining problems; all of them embedded in institutions and infrastructures." Over the last 250 years, major changes in socio-technical regimes associated with energy production, distribution and consumption have produced major if geographically highly variable impacts on rural Scotland.

Scotland's profound rural to urban shift of population in the nineteenth century provides a key challenge to historians. It can be attributed to both push and pull factors, with the Highland Clearances, the potato famine, Irish immigration and rural poverty major push factors and the rise of industrial capitalism the primary pull factor (Devine, 1999). But there is more than a mere rural to urban shift. It is possible that the single biggest factor driving *regional* variations in population change and economic performance in rural Scotland over the last 250 years has been energy production, not, as one might initially think, changes in the farming, fishing and forest sectors. On closer inspection of Scottish history, the rise of industrial capitalism is not wholly synonymous with large-scale urbanisation, as diffuse industrial developments adjacent to energy sources were critical at key junctures in Scotland's economic development. For example, Smout (1986: 18) writing about nineteenth century central Scotland, notes that "between town and country lay the many scores of industrial villages of central Scotland forming a characteristic social environment which was a blend of both." Changes in energy regimes have thus been crucially important in shaping regional variations in economic performance, from communities built around water power, to the industrial coal villages of central Scotland, to the aluminium smelter communities of the Highlands, to the explosive growth of areas such as Shetland based on oil and, finally, to the emergent identity of Orkney as a centre for marine renewables.

In the pre-industrial period, systems of energy provision were almost exclusively local; and, in some places, these local primarily subsistence energy systems have remained right through to the present. From the mid-eighteenth century, technological developments, especially in spinning and weaving, and the rising prosperity associated with early industrial developments led to a rapid growth in the demand for water power in the eighteenth century and an orientation of new manufacturing activity to waterside locations (Shaw, 1984). Later, over the nineteenth century, technical developments such as the steam engine, the widespread adoption of coke smelting, the extraction of gas and later the production of shale oils caused a surge in the demand for coal and related products. The central Scotland coalfield, running from Ayrshire to the Fife coast in a sash across central Scotland became the setting for coal-driven economic development, which, with the ready availability of limestone and iron ore, provided the platform for major agglomeration economies and significant demographic and economic growth. But like many other UK coalfields, many of the collieries were in villages. It was not until the 1960s, when a policy of concentrating on new super-pits was implemented to meet the continued demand for coal for electricity production and domestic use, such that many smaller "village" pits closed, leaving small communities, formerly almost wholly dependent on the pit, to decay. Alongside the post-war changes in the coal industry, in the 1950s and 1960s significant hydro-power developments were undertaken in the Scottish hills and uplands which had profound impacts on some rural areas. The discovery of hydrocarbons in the North Sea in the mid-1960s provides the penultimate stage of rural Scotland's energy economy, which was followed from the 1990s by a policy-led push into other renewables technologies, especially wind, but also solar photovoltaic (PV), biomass, wave and tidal energy.

These six socio-technical regimes (Fig. 13.1), from local mixed energy systems (Stage 1) to mechanical water-power driven (Stage 2), to coal-dominated power (Stage 3), to a hydro-electric power sub-regime (Stage 4), to oil and gas (Stage 5), to the wider renewables agenda (Stage 6), provide the context for an exploration of socio-economic impacts on rural Scotland. The transition from one to another was not contemporaneous across rural space, occurred with very different intensities of impact in different places, and often left still-functional components of earlier regimes. A combination of operational and cheap old energy technologies and path dependencies has created mixed energy systems, even if one regime tends to assert dominance for significant periods.

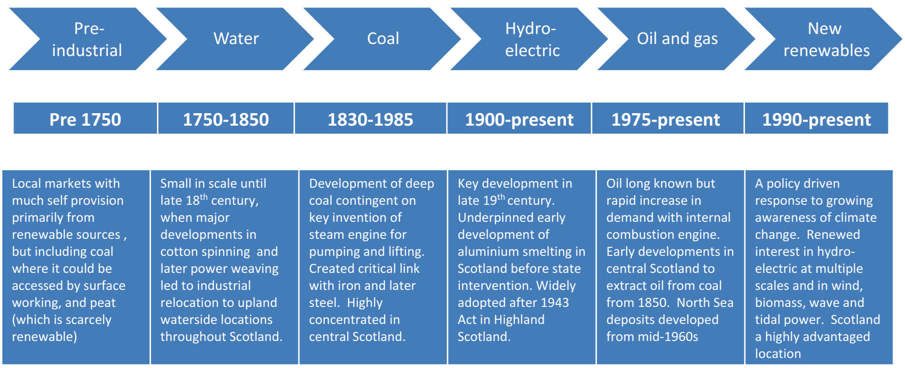

Fig. 13.1 Timeline of key socio-technical regimes in energy production impacting on rural Scotland

2 A Six-Stage Model

2.1 Stage 1 Preindustrial Energy in Scotland

In the pre-industrial period energy production and use was highly dispersed and localised whether for heating or for mechanical power. Several sources of energy were utilised: wood for heating; water for mechanical power; animals for draught power; and coal and peat where they were locally available and easy to extract. Wood was the dominant domestic fuel, although peat was utilised especially in island areas where wood resources were limited but everywhere that peat was an abundant or easier-to-exploit resource. Water resources were widely exploited using water wheels to create mechanical power which was used in milling, crushing, grinding and sawing operations (Shaw, 1984). Many of these installations were on farms and were often very small-scale, but many also powered artisanal workplaces. The widespread distribution of waterpower sources can be readily seen in a map of mills in Aberdeenshire, where it would seem likely that there were perhaps in excess of 1,500 watermills in mid-nineteenth century (Slee et al., 2009) (Fig. 13.2). Where the

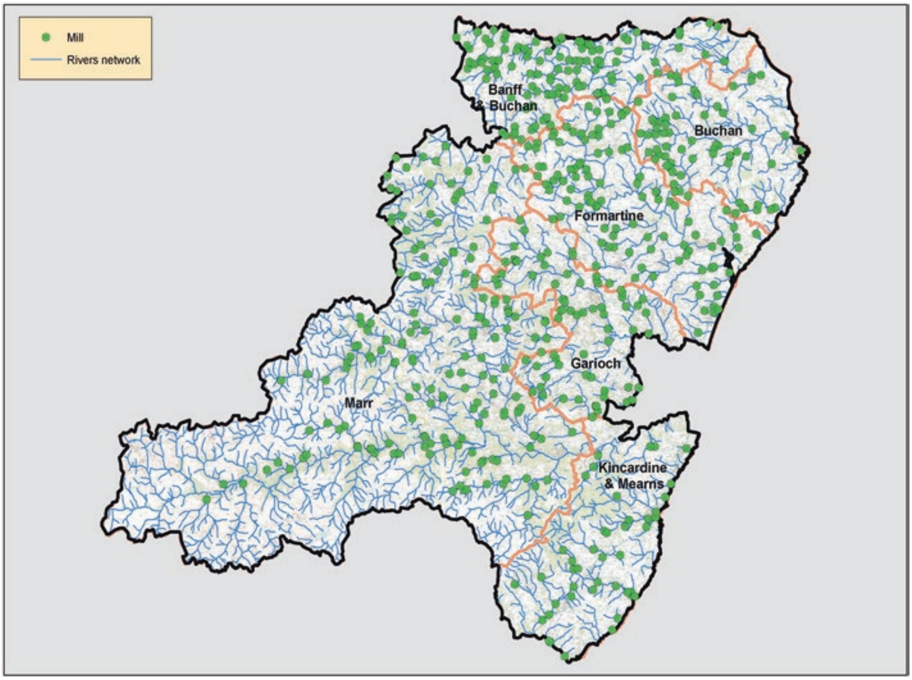

Fig. 13.2 Water power sites in Aberdeenshire. (Source: Slee (unpublished))

technology was intact and functional, there was little justification in shifting to a new regime which would entail additional capital expenditure and greater running costs. Some farm mills were still in use up to the 1970s. Fenton (1976: 89) writes: "in spite of this sequence of change and adaptation as new types of motive power came into being, the smaller farms nevertheless often stuck to the old ways that would serve them without great expenditure." The last water-powered woollen mills were operating to the 1960s. In addition, to the predominance of water power, wind energy was an occasional source of onshore power for milling (Fenton, 1976).

Energy for land transport was almost exclusively based on draught animals, with horses and oxen widely used, although the latter almost exclusively in farm work. It was not uncommon for different draught animals to be used either together or individually in different farming operations on a single holding (Carter, 1979). As well as their role in transport, animals were also used in providing mechanical power for grinding or threshing of grain, as evidenced in round open-sided barns found frequently in south eastern and central Scotland.

Navigable rivers are not a common feature in Scotland, though it is clear that water flow was used to transport timber down watercourses. In the streams of the Caledonian pinewoods of the Cairngorms, temporary dams were constructed, water held back, then released with an explosion to provide a flush of water to move timber downstream.

The deeply indented coast also meant that a significant proportion of the population could take advantage of sea transport. Coal may have transcended purely local markets, as coalfields near the coast offered relatively easy movement to other coastal locations. A marked feature of population distribution is just how much of the population lived within close proximity to the sea, or but a short distance from it. Bulky materials such as grains and timber which were exported and imported through ports must still have been moved short distances over land. Further south in England, water was used more widely as a medium in association with draught animals (or downstream currents, wherever possible) as it was much easier to move bulky materials in boats and barges.

A notable feature of the pre-industrial rural economy is how, with limited exceptions, energy production was a subsistence task rather than a market product. Household members gathered fuelwood or peat, often as part of wider crofting community activity. A very high proportion of farmsteads had mills, often of very modest proportions, sufficient only to meet household needs and able to operate only when water supplies were adequate. The importance of these sources of power is evidenced in property rights, especially for water and further illustrated in the frequency of disputes about water rights. In the pre-industrial period, energy was not widely marketed in rural areas but there must have been sales of wood and peat to urban areas. In the von Thunen model of land use (Haggett, 1965), woodland is seen as a dominant use close to urban areas because of the bulk of the material and its relatively high transport cost per unit value. Improvements in the road system began with the Wade roads in the mid-eighteenth century in the Highlands for military reasons and from the late-eighteenth century for civilian purposes, with Smout (1969: 238) describing them as the capillaries of the emergent transport infrastructure.

As pressure grew on charcoal as an input into eighteenth century iron smelting in the Midlands of England, there was considerable economic activity in the west of Scotland, where a charcoal energy source was available at competitive prices. Perchard and Mackenzie (2013) note that rather than being an exception to the penetration of market forces into Highland Scotland in the eighteenth century, the exploitation of charcoal was just another incursion into the region's natural resource base. Access to abundant wood resources "*was absolutely crucial in energy-intensive industries, such as the metallurgical sectors. Iron smelting, for example, combined local and inward investment and ores, with a plentiful supply of timber, proliferated across the Highlands between the 1720s and late 1860s*" (Perchard and Mackenzie, 2013: 6). In spite of the large demand for charcoal at Bonawe in Argyll which operated for 120 years from the 1750s Stewart, 2003) notes that the oakwoods exploited for charcoal were as extensive at the end of the period as at the beginning. Not all operations had such longevity.

2.2 Stage 2 Water

Water power and water generally were pivotal resources in the early industrial revolution, with major consequences on the growth and movement of population (Devine, 1999). The basic technology of mechanical power from mill wheels had long been known, but key technical developments in spinning and weaving in the last quarter of the eighteenth century (Arkwright, Hargreaves, Crompton etc.) and the first quarter of the nineteenth century stimulated a major upscaling of water wheel size for wool, linen, cotton and flax processing and manufacture. In the upland fringe of the Pennines, entrepreneurs like Richard Arkwright developed water-powered factory colonies which propelled growth in these places and led to the subsequent decline of previously important textile areas such as East Anglia. The wetter, hillier north and west of the UK including Scotland were soon to overtake and displace the textile industry of the south and east. Water energy in association with technical developments was everywhere the driver of these massive redistributions of economic activity and population to a relatively late date in the industrial revolution. According to Malm (2013: 27), "*by 1800, 84 Boulton & Watt (steam) engines in British cotton mills were still overshadowed by around one thousand water wheels. Water remained the foundation for the capitalist factory system, and not merely as a relic of the past: wheels were enlarged and perfected, dams and reservoirs excavated en masse, new and extended mills—particularly in the great cotton boom of 1823–5—equipped with the latest wheel-models of gargantuan dimensions*."

Water was also important as a means of transporting materials. Land-based transport was slow and road conditions routinely poor, so water provided a preferred means where possibilities arose. In the late eighteenth century canals were built, which, using animals for draught purposes, provided a means for transporting bulky materials, especially coal.

New Lanark was a typical Scottish industrial colony in its early development in the 1780s. Its cotton works were developed by Robert Owen's father in law in partnership with Richard Arkwright and when Owen became the mill manager, he championed the living conditions of workers and provided community facilities such as schooling at a level previously unknown in such settlements.

The period 1730–1830 in Scotland has been described as the age of water power (Shaw, 1984). In addition to the long-standing milling of grains and sawing of timber by water power, new industries, especially textiles, mineral processing and paper making led to the water-side construction of large numbers of new and larger water mills. Waterpower underpinned the early industrial economy and shaped the current pattern of urban development in parts of Scotland. Whatley (2000: 219) notes that 89% of all manufacturing employment in Scotland in the 1820s was in textile mills, the locations of which were primarily determined by water power. Devine (1999: 157) notes how much of the industrial expansion of the late eighteenth century was in rural areas and that as late as the 1830s, much manufacturing retained a rural location. This observation is reinforced by Withers (2006). Shaw notes how the major rivers of eastern Scotland provide a setting for diffuse industrialisation in the late eighteenth century and were principal formative influences on the creation of many small and medium sized towns.

Using Blairgowrie in Perthshire as an example, the propulsive effect of available water power on economic growth in the nineteenth century is clearly illustrated. Blairgowrie's population increased roughly seven-fold between 1810 and 1880 to around 7,000 people, with peak employment in the 14 linen and jute spinning mills of nearly 2,500 people. The expansion was entirely contingent on technical developments in spinning and weaving which enabled large-scale exploitation of water resources (Dawson, 1950). Flax (grown for linen) was widely cultivated as a field crop in the vicinity, with the spinning providing the means of adding value to the material.

Blairgowrie's expansion was mirrored in dozens of villages and small towns with accessible water supplies, especially at the edge of hills. Around 1800, fifteen miles to the east of Blairgowrie, a factory village had been developed at Stanley on the River Tay and for the next century and a half was a significant producer of different types of cotton (Fig. 13.3) with Richard Arkwright an investor. Huntly in Aberdeenshire has a parallel history of rapid expansion based on entrepreneurial developments in woollen cloth manufacture. Galashiels population in the borders almost tripled between 1851 and 1881 on the back of an expanding woollen industry (Brown, n.d.). Here the relatively late substitution of hand loom by the power loom enabled rapid industrial expansion from the 1850s. The majority of in-migrants came from the surrounding countryside.

Fig. 13.3 Stanley Mills Perthshire: A late eighteenth century cotton mill on the Tay River (Scotland). (Source: © Bill Slee (author, own photo))

The large-scale exploitation of water sometimes created disputes. The LRRG (2014: 214) reported that "*from the 18th century, with the importance of water power to the industrial revolution, the common interest rights of riparian land owners became increasingly contested in the courts*." Indeed, around the turn of the nineteenth century a dispute arose in Blairgowrie regarding the asserted precedence of potable water supplies over mill demands.

Almost all of these mills are now closed. The substitution of cheaper imported cloth led to a steady decline in these mills from the 1930s with many closures in the 1950s and 1960s. The effect on villages and small towns was large-scale unemployment. A contemporary map of many of rural Scotland's worst performing areas on the basis of Scottish Index of Multiple Deprivation (Scottish Government, 2016) highlights the decline of the mills and the absence of any major subsequent drivers of economic activity. This is the direct legacy of the decline of the water-based energy regime.

Some mills remained as functional businesses but primarily with outsourced production. Johnstons of Elgin are an example of a survivor. The firm is still located on the site of a woollen mill constructed in the 1790s but their current business model is based on the use of imported cashmere. Generally, where water power is still used, it is a result of the conversion of mechanical power to electric power through conversion to hydro-electricity, often still using the same lades. However, in central west Scotland, the cotton industry eventually became a highly concentrated industry when the earlier waterside location became less important as steam and coal replaced water power for driving machinery. This part of the textile story thus segues into the next socio-technical regime: that of coal.

There were several significant canals in Scotland but nothing like the density of canals that supported the economic growth of inland England from the 1780s. The Union and the Forth-Clyde canals provided water transport possibilities for the industrial hub of the Scottish economy. Additionally, the Monklands Canal took Lanarkshire coal to Glasgow; the Crinan Canal provided a short cut, inter alia, for Hebridean livestock being shipped to Glasgow; the Caledonian Canal was essentially a colonialist development project with military undertones; and a short-lived canal linked Inverurie and Aberdeen.

2.3 Stage 3 Coal and Shale Oil

Where coal outcropped at the surface or could be accessed by adit mines there had been exploitation from at least the Middle Ages. Its exploitation had increased between the sixteenth and eighteenth century but from the early nineteenth century the key development of the steam engine enabled the surface and adit mines to be replaced by pits. The timing of the development of the steam engine almost paralleled developments in the iron industry enabling coal to replace charcoal. Coal had long been exploited in a semi-rural environment. Smout (1969) describes the serfdom which for a century until 1799, characterised the coastal semi-rural coal mining communities of the Firth of Forth, where coal was widely used in salt manufacture (to evaporate seawater). Coal production later became centred on Lanarkshire with important outliers in Ayrshire, Stirlingshire, Fife and East Lothian and two isolated outliers in Kintyre and Brora. In all these areas, much coal mining was distinctly rural in character (See Oglethorpe, 2006).

Paralleling the situation in England where "*gaining access to a capital stock of energy built up over a geological era was also essential, since it meant that energy could be expended on a scale that was not otherwise available*" (Wrigley, 2013:4; Sieferle, 2001), coal provided the energy source which drove forward the industrial revolution in nineteenth century Scotland and provided the platform on which iron, steel and heavy engineering were established. But even by the mid-nineteenth century, Devine (1999: 157) notes how "*both coal mining and pig iron manufacture were also located in small towns and country villages*." Smout (1986: 18) described even mid-nineteenth century coal mining in Lanarkshire as being intimately integrated with smallholder subsistence farming.

Malm (2013) argues compellingly that through the steam engine, coal provides the source that could meet the energy demands of growing capitalist cities more effectively than any (then known) alternative. While water power caused a centrifugal flight to the hills, coal, coupled with increasingly reliable steam engines in workplaces and transport systems, enabled concentrated urban growth. Without coal as an energy source, the massive surge in urbanism in nineteenth century Scotland would not have been possible. But though coal provided that emancipatory force, its extraction still occurred in a landscape of industrial villages.

Coal production peaked in Scotland in 1913 at 42 million tons (Payne, 1985) when it employed 150,000 people. From the mid-1940s to mid-1950s about 25 million tons were produced by around 80,000 miners. By the early 1980s, production had slumped to 7 million tons with a workforce of 18,000. By the late 1970s, almost every deep pit in Scotland was running at a loss and deep pit coal production was doomed. Over 20 years, the economic heart was ripped out of dozens of mining villages in Lanarkshire, East Lothian and Fife, as three out of four miners disappeared from the workforce.

Coal was thus deeply implicated in the transformative industrialisation of central Scotland from the 1820s. The co-development of iron and steel industries, heavy engineering and the rise of shipbuilding was one half of Scotland's industrial history, with the other component- textiles being very much water power driven.

The twentieth century decline of the iron and steel industry in Scotland owes more to its failure to adapt and adopt new technologies, as well as some evidence of a moral commitment to old production centres, although the lack of availability of coking coal was also a major constraint (Saville, 1965). What is indisputable is that coal provided the fuel that kick-started the Scottish iron, steel and engineering agglomeration in North Lanarkshire and Clydeside. As coal declined, so did the rest of the agglomeration, in part because of the decline of coal, especially the absence of coking coal, and in part because of the iron and steel sector's own failures to adapt to growing international competition (Saville, 1965).

2.4 Stage 4 The Hydro Power Boom

Hydro-electric power was first produced at Cragside, Northumberland by William Armstrong 1878. Within five years, there were commercial plants operating in the United States and within three decades, hydro-electric schemes were developed in many parts of the world. In Scotland, over the late years of the nineteenth century and the early years of the twentieth century, hydro-electric schemes were developed for private use by large estates and by industrial plant at Kinlochleven (established 1909) and Fort William (1929). Perchard (2013: 1) notes that British Aluminium's pioneering development of aluminium smelting based on hydro-power had "profound economic and social impact both locally and in the region as a whole". The first scheme providing electricity to public users in Scotland was at Fort Augustus, where a scheme was developed in 1890 to provide the Benedictine Abbey and the 800 inhabitants of the village.

The major impetus to hydro-electric power development in Scotland came from during the Second World War with the Hydro-electric Development (Scotland) Act 1943. Tom Johnston, a radical Clydeside MP and wartime Secretary of State for Scotland, modelled the North of Scotland Hydro-electric Board on the Tennessee Valley Authority in the United States driven by a desire to provide electricity to rural communities and underpin economic development in the region (Wood, 2005; Slee et al., 2009).

The 1943 Act precipitated a major development of hydro-power in the north and west of Scotland with the first major plant Sloy, opened in 1950. SSE (n.d.: 3) note that "*all this work was achieved by a workforce that averaged*

4,500, and which, at its peak, numbered about 12,000. In many cases, the workforce was made up of a mixture of British workmen and German and Italian former prisoners of war. This provided a significant financial boost for the area but was not always welcomed by local landowners, many of whom had a vested interest in keeping the Highlands exactly as they had been for years before." The skilled workers such as tunnellers could earn more than ten times the average estate worker's wage, but the workforce, rather than being grounded in the locale, was highly mobile and largely resident in work-camps as at Cannich in rural Inverness-shire. The largest camp housed around 3,000 workers. The extent of local employment created is uncertain, but with a population of around a quarter of a million in the 1950s, construction of hydro-electric power plant was a significant employer in a region where, at the time, unemployment was high and well-paid work was scarce.

By 1965 the output of the 54 main power stations was over 1,000 MW. Cruachan in Argyll, commissioned in 1965, was, at the time of its construction, the largest reversible pumped storage scheme in the world. Over the six years of its construction it employed 1,300 men in deeply rural North Argyll-shire. Foyers pumped storage scheme, built on the site of a failed aluminium factory and commissioned in 1975, was an outlier from the post-war flush of hydro-power developments which ended in 1965 with Cruachan. After 1975, there was a lull in hydro-electric developments until climate change entered the policy agenda and stimulated renewed interest in hydro-electric power from the late 1990s. We return to those developments in the penultimate section of this chapter.

It was over the 1940s and 1950s that many communities substituted mains electricity for the stationary engines or occasional isolated hydro-power turbines that had provided electricity to such parts of rural Scotland that used electricity. Brassley et al. (2017) comment on the high cost of connection of isolated rural dwellings to private electricity companies, but after public ownership in 1945, the fixed costs of connection were spread among all consumers. In the upland fringe and the Highlands private hydro-power plants often fell into disuse at this time as it was easier to buy the relatively low-priced power from the grid.

2.5 Stage 5 Oil and Gas

The first oil was discovered in the northern North Sea in 1969. This began a period of frenzied investment with the first oil coming ashore in 1975 and oil output peaking in 1999 (Liddell, 2014). An adverse balance of payments situation made the rapid development of the resource a national priority (Devine, 1999). The oil and gas industry can be seen to impact rural Scotland in three ways. First, in the construction phase there were a number of construction yards in deeply rural locations mostly in Highland region (Nigg: peak employment 5,000), Ardesier (peak employment 4,500), Kishorn and occasionally in the Western Isles (Arnish on Lewis) and two major oil handling depots on Flotta (Orkney) and at Sullom Voe (Shetland).

Second, the booming oil industry created lucrative employment opportunities for skilled and unskilled workers throughout the UK but with concentrations near access points to rigs and on-shore employment. For rig work (always a smaller proportion than the on-shore workforce), people could afford to live at a substantial distance from the heliports or harbours which provided a gateway to the rigs. The scale of the industry and the scale of the wealth oil and gas exploitation generated produced a huge number of jobs in related sectors and in sectors which were beneficiaries of the spending power of oil and gas incomes.

Third, the way the public sector has engaged has impacted on national and regional economies. Oil and gas were major imports and the UK economy had experienced a significant period with a negative balance of payments. From a Scottish perspective, there had long been a concern that North Sea tax revenues were not being reinvested in Scotland and comparisons are often made with Norway, which has used a Sovereign Wealth Fund to support infrastructure spending including in rural areas. 'It's Scotland's oil' became a rallying cry of nationalist politics. The repatriation of oil tax revenues was still a deeply contentious issue at the time of the independence referendum in 2014. At a more local scale, smart councils, in effect one smart council, Shetland, was able to derive substantial long-term income stream from the exploitation of oil in the sea surrounding the islands, very much along Norwegian lines. Gavin McCrone, former Scottish Office chief economist wrote in 2011 that "*the way in which North Sea oil has been handled by the council has given the community immense benefits, benefits which have not been evident in the rest of Scotland or the UK. Much of the credit for this must be given to the council's then chief executive, Ian Clark, a man of exceptional foresight and determination in some very difficult negotiations with the oil industry*." The Council negotiated a private parliamentary bill which gave them a local tax on all oil landed in Sullom Voe, which was invested in an arm's length community fund which generated an income of over £11 million in 2011.

The Highlands and Islands Development Board had been established in 1965 to support the development of the region. It actively supported oil-related developments, which can be seen as an important contributor to their aim of reversing the long-term population decline of the region. This reversal of population decline was achieved but the population turnaround was by no means even, and the areas of greatest gain were almost always linked to oil industry developments.

The construction phase was dominated by a search for deep-water sites suitable for large-scale construction of rigs, which extended from Clydeside, to Fife, to the Western Isles, to the west coast of the Highlands to the Moray Firth, with further proposals for a number of sites that never came to fruition. A significant local workforce was recruited locally but specialist welders and other staff often came from further afield. Such were the concentrated demands for labour that it was often essential to develop quasi-colonial work camps.

At its peak, total UK employment in oil and gas was about 400,000 people, of whom 220,000 were employed in Scotland. On average, oil and gas incomes were much higher than the Scottish average, meaning that the impacts of that spending rippled through local economies. Oil prices have always been volatile but a major and long-lasting fall in oil prices in 2014 has led to significant labour shedding. Vaughan (2017) reported that "*the industry had already been hollowed out by the 2014–16 oil price slump, falling from a peak of nearly 500,000 employed in 2014 to 315,000 at the end of 2016*."

2.5.1 The Scottish Mainland: Oil and Gas

The main focus of the mainland economic activity in relation to North Sea oil and gas has been Aberdeen and Aberdeenshire with outliers to the south in Angus, Dundee and Glasgow, and to the north in the Inner Moray Firth and briefly Kishorn in Wester Ross. The rural dimension of employment was much greater in the construction phase with the Inner Moray Firth especially important, with outliers in Clydeside and Wester Ross. However, the offshore nature of a considerable proportion of work in the production phase and the two or three-week shifts mean that workers are often willing to travel large distances; more so given the very substantial wages premium. As the industry enters a decline phase, there are some new employment opportunities arising from decommissioning and the original construction areas have obvious advantages.

Once the early construction boom passed, the temporary camps were removed and the pulse of high incomes into many local communities returned to more normal levels. Those whose appetite for high incomes was whetted could travel further afield or travel to offshore jobs. Oil remains an important income source for many households in the region providing a very substantial but largely invisible (because there mostly were no local premises) injection of wealth, especially into the rural economies of Aberdeenshire and Moray.

2.5.2 The Scottish Islands: Oil and Gas

The key island group affected by the changing fortunes of the oil and gas sector has been Shetland. Shetland Islands Council (2010: 9) note that "*after decades of decline the population of Shetland, which had fallen to nearly 17,000 in the mid-1960s, rose by 31% between 1971 and 1981 as a direct result of oil related activity. The island construction sites were very labour-intensive operations that employed large numbers of people in the boom years. Sullom Voe in Shetland employed 7,000 people during the construction period in the 1970s and c. 600 when functioning*." Shetland remains a key access point by air or sea to many northerly oil platforms. The oil-induced change in Shetland's economic fortunes was remarkable (McDowell, 1975). At the start of the 1970s Shetland unemployment was 123% of the UK average and average earnings 70%. By 1981 unemployment was 45% of the UK average and earnings in Shetland's non-oil sector were at UK average levels. Orkney had much more localised engagement, as did Lewis in the Western Isles. The Orkney island of Flotta (population 80 people), employed 1,200 people at its peak in building Occidental's oil terminal, mostly comprising "imported" workers but including some islanders (Simpson, 2011).

Oil profoundly impacted on the cultures and traditional ways of life of the islands, where many people had tolerated lower incomes because of a strong place attachment. The oil worker was the archetypal footloose employee, willing to accept the considerable deprivations of disrupted family life for the financial reward of shift-work at a distance. Their lifestyles sometimes jarred with those of local residents. In the mid-1970s, I was told by an Orcadian farmer that his son could earn more in a month cleaning lavatories on Flotta than he could earn in a year on a small farm, thus undermining the land ethic at the core of Orcadian island living.

2.6 Stage 6 Renewables

The emergent understanding of the link between fossil fuels and anthropogenic climate change from the 1980s created the preconditions for the rapid expansion of renewables globally. Although government had long taken a strong interest in energy, as in the 1943 act enabling hydro-power exploitation and in the nationalisation (and later re-privatisation) of coal and power, the latest regime can be seen as primarily public policy-driven, rather than driven by markets, entrepreneurship, profit seeking and industrial capital. This is a decisive shift from the preceding regime in spite of the earlier government engagement with energy policy.

Scotland, and especially Northern Scotland and its islands have emerged as highly advantaged locations for the production of renewable energy (Murphy and Smith, 2013). Its onshore and offshore wind resources, wave and tidal resources are among the best in Europe and there is still unexploited hydropower potential at multiple scales (Forrest et al., 2008). There is also scope for biomass schemes using abundant low-grade wood (Okkonen, 2008) and potential for geothermal energy (AECOM, 2013). The emergent renewable energy mix and its geography are both a function of the resources, the availability of grid connection (where electricity is involved) and the suite of policies and levels of support for different types of renewables. Some of the technologies are well established but still developing (on-shore wind, hydroelectric and wood); some are at a rapid development stage (off-shore wind and tidal); and some are still very much in the development phase (wave and geothermal). Scottish Renewables (2018) report that "*onshore wind is the biggest single technology, accounting for over 72 per cent of installed capacity, while hydro, solar and bioenergy are Scotland's other major sources of renewable power*." In relation to projects under construction, on-shore and offshore wind are overwhelmingly the largest with photovoltaic and tidal at about ten per cent of the level of both on-shore and off-shore wind.

One of the marked features of the new renewables phase is the adaptation of technology across a range of scales, with many more small-hydro schemes, some using 'new-old' technologies such as the Archimedian screw. A similar scaling up and scaling down operates with wind turbines with a size range from a few kilowatts to 8 MW in major offshore turbines. A democratisation of ownership of renewables has taken place which has proceeded fastest with photovoltaics but, even with photovoltaics, industrial scale installations are planned for rural Scotland in Morayshire. This democratisation means that households and land managers can take advantage of the multiple scales of technology on offer and engage in energy production.

A further feature of the new regime is the ability of the new technology to build on the experience and skills of the earlier regime, most obviously in the construction technology for off-shore wind farms. Many of the yards where oil and gas installations were built have morphed into suppliers of off-shore turbines.

The evolving regulatory system has increasingly enabled the engagement of a wider range of institutions with energy supply and distribution from corporate to municipal to private and third sector forms. Bauwens (2017) notes the polycentricity of renewables governance. Borrowing from Ostrom's principles, he (op cit.: 3) describes polycentric systems as involving "*the coexistence of many self-organized centers of decision-making at multiple levels that are formally independent of each other but operate under an overarching set of rules*." This aptly describes the context of renewable energy production in Scotland in 2018.

2.6.1 The Scottish Mainland: Renewables

On the Scottish mainland, the legacy of oil and gas has offered a platform of opportunity to the developing renewables sector. The former rig construction yards are highly suited to the construction and loading of offshore wind components, though generally the percentage of Scottish manufactured components has been very low with low resultant impact multipliers (Allan et al., 2007). Nigg at the south eastern corner of Easter Ross was an oil rig construction site. It is now effecting a partial transition to renewable energy (BBC News, 2011). In 2011, the former platform construction site was bought to be transformed into a multi-use energy hub servicing oil and gas and renewables creating 800 jobs. This is rather less than the boom-time of the 1970s and 1980s when the site employed up to 5,000 people. Ardersier, a 340-acre former rig construction site was also earmarked in 2013 as a possible site for wind energy construction (BBC News, 2013) Even coal mine shafts have emerged as places where renewable energy might be produced either through thermal schemes or by means of a modern take on pumped storage (Scottish Energy News, 2018)

There is a distinct geography of contemporary renewables production, with wind energy concentrations in areas of lower scenic value, but with other technologies generally more tolerated by planners, but in the case of hydropower tightly regulated by the Controlled Activity Regulations administered by SEPA. The largest wind turbine complexes are major landscape features that match or even exceed the scale of the large hydro dams of the earlier hydro-power boom.

2.6.2 The Scottish Islands: Renewables

The Scottish islands have long been recognised as a place of considerable opportunity with respect to renewables, with high average wind speeds, and abundant marine energy resources. Grid connection has, however, been a major constraint on developments. This has not stopped the islands repositioning themselves to take advantage of the emergent opportunities; a process which finds strongest expression in Orkney, which, with the exception of the Occidental Oil terminal constructed on the Scapa Flow island of Flotta, was largely by-passed by 1970s and 1980s oil developments (Anon, 2017). Orkney has secured substantial inward investment relating to marine renewables and hosts the European Marine Energy Centre which provides support and testing of technologies and describes itself as 'world-leading'. Arnish on Lewis owned by Fife-based Burntisland Fabrications Ltd. was revitalised by renewables contracts, but in February 2018 is threatened with closure in the absence of new orders.

The fortuitous link between oil and renewables development is evidenced in Shetland in the council's investment in the huge Viking Energy project in collaboration with SSE (McCrone, 2011). This is not the normal Scottish model of community renewable energy but is much closer to the Nordic model where municipal and private corporate investors are the developers. A part of the large accumulated oil fund has been invested in this development.

The western and northern isles have been the setting for a significant development of community renewables (Okkonen and Lehtonen, 2016). Community ownership of land has helped enable wind turbine developments as communities have been empowered to make development decisions (subject of course to planning approval). Such developments are normally between 1 and 10 MW (most are around 1 MW) and most are in the hands of community development trusts which plough the revenue generated into community development activities. Support from Community Energy Scotland is likely to have been decisive in bringing a number of such schemes to fruition as is support from the Scottish Government's CARES scheme (see Hargreaves et al., 2013). Indeed, there is contestation on islands such as Lewis between local ownership and external ownership.

3 Contemporary Development Challenges

The future development and shape of renewables development will be decisively influenced by UK rather than Scottish policy. This is explored elsewhere (Wood, 2017a, b; Slee and Harnmeijer, 2017). There is some scope for Scottish influence on policy (see Slee and Harnmeijer, 2017) particularly through planning policy but also through funding of pilot projects and the provision of institutional and financial support to renewables developments.

Recent developments in renewables in Scotland starkly expose some of the key issues that will determine the impacts of the transition to renewables in the Scottish rural economy. These include the pricing mechanisms, the extent to which policy steers community engagement, including co-ownership, and the trade-off between grid improvement and re-localisation of grids. The direction of travel of policy is unclear. With the new Contract for Difference pricing policy, the post 2016 energy policy landscape seems to favour large-scale corporate ownership rather than community engagement. The Scottish Government's rhetoric suggests an engagement with community, at the same time as driving the energy transition through corporate power. While the recent discussions at UK level have alluded to the possibility of an enhanced community Feed-in Tariff (FiT), nothing emerged in the subsequent legislation. Such community engagement as there is seems more likely to be built around co-operative shares in larger projects, which lacks the embeddedness of the community development trust model, with its capacity to inject really substantial sums into community development (Harnmeijer et al., 2018). Notwithstanding the useful support from the CARES scheme which has helped bring community schemes to fruition, the major drop in FiTs at UK level means that a more favourable planning regime for community renewables in Scotland would currently be largely meaningless.

4 The Impacts on Rural Scotland

4.1 History or Historiography?

There is a long-standing tradition of historiography in public discourse about rural-urban distinctions in the UK which is grounded in sentiment and misinterpretation in the face of abundant evidence to the contrary (Burchardt, 2007). Devine (1999: 464) bemoans "the textbooks' focus on ploughmen, women workers and bothymen" whilst ignoring other rural trades. There are two elements to what we might term the dominant agrarian discourse that has shaped perceptions of rural Scotland's history. First, areas that are disadvantaged for agriculture are seen as problem regions, and indeed long have been. Such a view underpins Mackay and Buxton's (1965) apparent willingness, ironically the year of the formation of the Highlands and Islands Development Board in 1965, to question any intervention to improve the Highlands and Islands economy, a view which is challenged, *inter alia*, by Perchard and Mackenzie (2013). The second related facet of the agro-centric historiography on rural Scotland is that the rural economy hinges around the agricultural sector. Notwithstanding a significant food processing industry in some regions, such as Aberdeenshire and Morayshire (Cook et al., 2016), the overwhelming majority of rural jobs created in the last fifty years in rural Scotland has been in services; or if rural is defined by residence rather than by place of work, in urban jobs to which people commute from rural residences. There is thus a persistent trait in commentaries of rural Scotland to understate the role of the non-farm sector in rural regional development, and this includes neglect of the energy sector's role as a decisive influence on differential patterns of growth and decline in rural Scotland.

4.2 An Energy Timeline

With respect to energy production, there is not a simple regime shift, although the dominant regime has changed, in the early part of the period as a result of market forces but more recent shifts are attributable in large part to public policy. The energy baton is not passed to a new regime with the consequential demise of the earlier regime. Often parts of the old regime keep running, even if dominance has changed. In practice, some of the old technologies have surprising staying power. Pre-industrial regimes remain in the cutting of peat and the local use of firewood, now supported by technical adaptations around pelleting and woodchip and mechanical cutting of peat. There remain a few water-powered grain mills, a pre-industrial legacy but where scale was often ratcheted up to meet more than local demands in the textile industry, most waterwheels have converted to hydro-electric turbines as at Stanley, New Lanark and Grandholm in Aberdeen.

5 Rural Life in the Shadow of Fossil Hydrocarbon Decline: Opportunity and Challenge

As pressures increase to decarbonise economic activity there is a need to assess the positives and negatives for rural Scotland. On the positive side, rural Scotland has a diverse natural capital base highly suited to renewables development. On the negative side, some of the technologies associated with some renewables sectors have very weak linkages to the Scottish economy. Many of the renewable developments generate relatively little employment. Further, rural households are more car-dependent and have on average more poorly insulated homes placing higher demands on fossil fuel energies and technologies and are thus hit hard by any attempt to decarbonise the economy by raising electricity prices to pay for renewables or by taxing greenhouse gas emissions. A further negative factor is that Connolly et al. (2016) point to a decline in the number of jobs in the renewable sector as the technology matures.

Allan et al. (2007) also point to the weak intra-Scottish linkages of onshore renewables compared to coal. Coal's embeddedness in the Scottish economy created strong backward linkages, and North Sea oil and gas exploitation eventually generated strong onshore linkages. Although the situation is better for hydro-electric generation than for on-shore wind (where most components are manufactured out-with Scotland), the strongest linkages appear to be with marine renewables, though the authors note that the currently high multiplier effects may be an artefact of the early stage of development of the technologies.

Local ownership creates much higher levels of benefit (Allan et al., 2011; Phimister and Roberts, 2012), as illustrated in models of the Viking Development in Shetland and studies of small-scale farmer and community ownership in North East Scotland show. However, community ownership may be associated with higher development costs (Berka et al., 2017), thereby making some proposals less viable.

Burrell (2011: 45) makes the case for public policy support for rural energy. She argues that:

> interventions should be time-limited in order to avoid creating vested interests and—the reverse side of the coin—existing obsolete policies should be phased out despite any opposition from vested interests already created. Any genuine public good items deemed necessary for attaining the objective should be identified and, subject to the usual ex ante (cost-benefit) evaluation, should be provided. The focus should be on the whole chain of a product or activity, rather than simply one segment of the chain (the most vociferous?), in order to optimise the choice of where to intervene if intervention is deemed necessary. Barriers to market entry should be removed at all points in the chain, and the infrastructure for the correct functioning of each market in the chain should be in place. These are all actions within the remit of government policy.

Given the imbalances of power relations and the persistent desire of governments (including Scotland's) to reduce regional imbalances in wealth and economic activity, the lack of any redistributive component in this restatement of neoclassical imperatives for policy intervention might be seen as an omission, but the efficiency component of the case for policy intervention in renewables is nonetheless well made.

5.1 Impacts of Renewables on Employment: Continuing and Increased Delocalisation

Renewable energy systems have not generally created large amounts of employment beyond that needed in the construction period. With modern electronic monitoring and control systems large wind turbine complexes are largely unmanned on site. This contrasts markedly with the intensely localised employment in say coal mining, before the demise of deep-mined coal in Scotland. Although the new technologies delocalise employment they do not necessarily urbanise it. This process continues and possibly intensifies a narrative of delocalisation of labour that began with the use of mobile labour in the post-Second World War hydro-power power 'project' and which continued in the oil and gas era. Offshore production systems tend to further exaggerate the delocalisation of labour through fortnight on, fortnight off shift work.

It is almost certain that the contribution of energy to regional GDP is very significantly greater than its contribution to employment, as soon as the regime moves beyond the construction phase. For regions to benefit more, local ownership is key. One way in which this has happened is through household or farmer ownership of renewable energy production means. This repatriation of production might become more frequent if and when the problem of intermittency of supplies is overcome by reasonably priced batteries.

5.2 The Persistence of Public Support in the Deepest Problems in the Areas of Energy Decline

Given the high importance of fossil energy to the Scottish economy over the last 150 years there is an inevitable tendency to want to protect the energy sector's jobs regardless of global policy imperatives to cut carbon emissions. This was evident in the deal between nationalised electricity generation and the coal industry in the 1950s, 1960s and 1970s and in UK, Scottish and local government support to the oil and gas sector in the recent (post 2014) oil recession.

The former coalfield areas of central Scotland, particularly the smaller coal dependent communities remain some of the disadvantaged communities in Scotland using the Scottish Index of Multiple Deprivation. Some of these areas have been the setting for large scale on-shore wind developments, but almost all are in corporate hands and the community energy movement has scarcely touched these areas. Renewables may have emerged phoenix-like from the ashes and spoil heaps of the coal industry, but it has benefited shareholders of multinationals rather than local communities.

As with coal, so with oil. The major oil price drop in 2014 signalled strong public agency engagement with the loss of employment. Shetland is undoubtedly the most oil-dependent council area in Scotland and threatened and actual job losses in oil and gas have led to attempts to alleviate the social and economic costs. It is entirely understandable that Shetland wants to retain the Sullom Voe complex. Not only does it provide a major source of employment, but the landings still generate a revenue stream for the council. Equally, Highlands and Islands Enterprise (HIE) has been keen to support the transformation of oil construction sites to renewables construction sites or depots. One could not expect development agencies or councils to act otherwise, but one might hope for the short-termism of protecting jobs to be matched by a vision of the future as is evident in both Shetland's and Orkney's positioning in the renewables field.

6 Conclusion: A Long Goodbye of Several Different Regimes: As It Has Always Been So Will It Most Likely Be

Rumours of the impending demise of a particular energy regime tend to be much exaggerated. Only one country to date has permanently shut down a functional energy technology, with Italy's shutdown of nuclear power in 2011. In the wake of the Fukushima disaster in Japan, a number of countries have committed to phase out nuclear power with Germany, which produced 25% of its electricity from nuclear power stations, perhaps the most prominent.

There are obvious reasons for the drawn-out nature of the demise of different regimes. The European Environment Agency (2017) describe the social, economic, technical and political lock-ins or path dependencies that inhibit the adoption of new technologies., but also note, more optimistically, (European Environment Agency, 2017: 9) that "*historical case studies indicate that change in socio-technical systems 'polycentric' modes of governance follows a 'punctuated equilibrium' path, implying long periods of stability and incremental change interspersed with relatively short and sudden periods of disruption and 'waves of creative destruction' (i.e. transitions)*."

Our historical perspective on energy in rural Scotland bears out the observations about the slowness and uncertainty of the speed of change and shows that in rural energy production and use elements of earlier regimes were often not completely replaced. Water mills are still milling oats in a few places nearly 200 years after the end of the era of water driven power. Highly localised energy production systems often persist in the rural economy because of the sunk costs of the earlier regime and the ability to continue to draw benefit from that regime which may be compounded by peripherality and marginalisation. This is most likely with small isolated businesses such as woollen or grain mills.

Notwithstanding the diverse nature of rural energy systems and the high level of lock-in to past systems, the transformational changes in complex socio-technical systems such as those producing carbon-based energy are likely to be complex and drawn out affairs, driven by a myriad of economic, political, social and technical forces beyond the specificities of rural Scotland.

6.1 Institutional Architecture and Rural Development Outcomes

The impact of the emergent renewables regime on rural Scotland has been and will continue to be shaped strongly by the institutional architecture, comprising laws, policy instruments affecting the energy sector and planning as well as institutional regulatory and support structures. Large parts of the energy system (coal and electricity generation) passed from largely private ownership to nationalised industry in the 1940s and back to private ownership in the 1980s. At about the same time as coal and electricity were privatised, the state engagement of the public sector in oil and gas through the British North Sea Oil Corporation and part ownership of British Petroleum was ended. This institutional architecture is the result of political choices. In Norway, the state has had a much stronger shaping hand in the way oil developed and the way in which the wealth was used. In Germany and Japan, non-nuclear commitments have profoundly affected the direction of travel in the renewables sector. In the energy sector, the state at local and national level is rarely a mere regulator and rule setter and a resurgence of public engagement in electricity supply is by no means impossible, most likely at municipal rather than national level.

Decoupling from former energy regimes which still have strong legacy effects on rural and peri-urban regions, from oil dependence in North East Scotland and Shetland to coal dependence across the relict mining communities of the central belt will neither be fast, nor easy. Government will often intervene to postpone the demise and soften the blow.

What is clearly evident is that, apart from a relatively brief period from 1943 to the mid-1960s and the burst of community energy activity nurtured mainly by Community Energy Scotland in the first decade and a half of the new millennium, the rural as distinct from national dimension has not really been considered as a force in rural economic development, except insofar as rural areas have been the geographical setting for many large-scale, energy-related developments.

Scotland was advantaged by its abundance of water which underpinned the textile industry until well in the 1830s, often in deeply rural locations, villages and small towns. Its coalfields provided the next phase in drawing in a population, mostly from the surrounding countryside to work in the expanding pits which in turn underpinned the development of iron steel and engineering industries. While the coalfield villages often remained semi-rural, the increased ability to move the energy to the increasingly urban-located manufacturing centres enabled urban growth. Hydro-power emerged as another rural phase in Scotland's energy history, again bringing energy-hungry industry in its shadow. Oil and gas, as well as massively altering the fortunes of urban centres such as Aberdeen and Peterhead, also profoundly affected the rural areas of Scotland, most strongly at the construction phase of offshore platforms, but also in providing island-based storage and transit points. As coal had drawn in a workforce from the surrounding countryside so did oil, but with enhanced mobility many workers continue to live in rural areas, where residential preferences for rural living fitted comfortably with the need to commute not daily but fortnightly. So, energy extraction and production and its allied industries have been profoundly important in shaping and injecting wealth into contemporary rural Scotland.

Ownership or shared ownership of renewables seems likely to be a factor in determining its acceptability to rural people (Slee, 2015). Based on surveys in Clydesdale, Shamsuzzoha et al. (2012) note how opinions on local wind energy installations are shaped by the nature of ownership, an observation supported by circumstantial evidence elsewhere in Scotland and the UK. With community ownership, comes scope for local beneficial impact. Berka and Creaner (2018: 3414) note that "*overall, the evidence suggests that the most substantial local impacts are associated with indirect project outcomes and investment of project revenues in the local community*."

Perhaps because of their boundedness, islands provide interesting laboratories. Bornholm and Samsoe in Denmark both have strong identities built around renewables. Orkney is moving in such a direction. The piloting of post carbon futures in such places makes great sense.

6.2 What are the Implications for Rural Scotland of a Low Carbon Future

As rural Scotland faces up to the decarbonisation of the energy system, what are the implications? Scotland's rural areas have seen transformational change in their energy sectors, but all too often rural citizens have been bystanders in the development as employees rather than active investors. Many have taken jobs in the energy sector, but the bulk of the development has been in the hands of large-scale corporate owners. In relation to on-shore wind, developments have resulted in community funds, likened by one community energy activist to the offer the beads and necklaces offered to natives by colonial explorers. Ownership is not wholly corporate as some communities have invested in renewables (Harnmeijer et al., 2012) and, additionally, the North East of Scotland has a strong concentration of farmer-owned turbines (Cook et al., 2016). But the bulk of renewables provision is and will remain in the hands of transnational corporations.

The impact of a low carbon future on rural areas extends beyond jobs and occasional ownership of energy production. Rural people need private cars more than urban residents and the decarbonisation of transport will place particular pressures on rural people. The juxtaposition of renewables and hydrogen production will almost certainly enable hydrogen-powered transport and the deeper penetration of electrification of car transport is now proceeding. Electrical cars are currently more expensive than the petrol or diesel alternatives. An improved infrastructure of charging points will be needed. On island communities, where shorter journeys prevail and there are abundant renewable energy supplies, electric vehicles may well predominate. However, for farm, forestry and commercial vehicles, hydrogen power or biofuels again sourced from renewables are likely to kick in at some point as technologies mature.

Rural homes are mostly off-gas. Many are old and not thermally efficient. Space heating is Scotland's biggest demand sector for energy. Electricity, oil and LPG are the major means of space heating in rural Scotland. Rural areas of Scotland have some of the highest levels of fuel poverty in the UK. So, any taxation of fossil energy to 'make the polluter pay' will impact particularly on rural users. In many parts of Scotland there are abundant sources of wood and new more efficient stoves and pelleting and chipping create new possibilities for domestic and district heating, but gas remains so cheap at present as to deter many, although with a higher Renewable Heat Incentive more could be achieved. Pollution remains a concern as wood stoves, especially old stoves, can increase emissions of particulates.

The most decisive shift in rural wellbeing arising from to the transition to renewables would arise from shared ownership of the resource, involving a re-democratisation of ownership not through shareholdings held by affluent investors in corporate energy producers, but in re-democratisation into community ownership where communities are active stakeholders not the passive recipients of a community benefit fund. The community development trust has proved itself as a model in the opinion of some with respect to renewables developments (Riddoch, 2013). But a deepening of community ownership looks rather challenging given the existing support structures for renewables which favour corporate engagement (Strachan et al., 2015).

If rural Scotland can develop a more expansive vision of a post-carbon world, including but going beyond a narrowly agrarian vision that has constrained it in the past, the opportunities are abundant, not only in making use of some of the best resources in Europe for renewable energy production, but in developing smarter local storage systems and local grid around local ownership, especially in the islands, in stimulating innovation to support the transition to a post-carbon world. The realisation of that vision will depend on reshaped institutional architecture, including new public private collaborations that embrace communities as well as municipalities and a willingness to build on the earlier visions of people like Tom Johnston. It will also depend on effecting as least painful a transition for those who live work and drive in Scotland's rural areas as possible, helping them not to be treated as scapegoats for the fossil fuel age but as architects and leaders in the transition to a post-carbon world.

References

AECOM. 2013. *Study into the Potential for Deep Geothermal Energy in Scotland*, Scottish Government Project Number: AEC/001/11.

Allan, G., McGregor, P.G., Swales, J.K. and Turner, K. 2007. The Impact of Alternative Electricity Generation Technologies on the Scottish Economy: An Illustrative Input-Output Analysis. *Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy* 221(2): 243–254.

Allan, G., McGregor, P. and Swales, K. 2011. The Importance of Revenue Sharing for the Local Economic Impacts of a Renewable Energy Project: A Social Accounting Matrix Approach, *Regional Studies* 45(9): 1171–1186.

Anon. 2017. *Orkney Sustainable Energy Strategy 2017–2025*. http://www.oref.co.uk/wp-content/uploads/2017/10/Orkney-Sustainable-Energy-Strategy-2017-2025.pdf.

Bauwens, T. 2017. Toward Polycentric Low-Carbon Transition: The Roles of Community-Based Organizations in Enhancing the Resilience of Energy Systems. In: Labanca, N. (Ed.) *Complex Systems and Social Practices in Energy Transitions*. London: Springer, pp. 119–145.

BBC News. 2011. *Nigg Yard to Be Redeveloped Creating Jobs*, October 20, 2011. http://www.bbc.co.uk/news/uk-scotland-highlands-islands-15382061.

BBC News. 2013. *Plans for Rebirth of Ardesersier Yard*, May 6, 2013. http://www.bbc.co.uk/news/uk-scotland-scotland-business-22424941.

Berka, A. and Creaner, E. 2018. Taking Stock of the Local Impacts of Community Owned Renewable Energy: A Review and Research Agenda, *Renewable and Sustainable Energy Reviews* 82: 3400–3419.

Berka, A., Harnmeijer, J. and Slee, B. 2017. Crossing the Rubicon: The 2015 Renewable Electricity Reforms and the Implications for Scotland. In: Chap. 8 of Wood, G. and Baker, K. (Eds.) *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Cham, Switzerland: Palgrave Macmillan.

Brassley, P., Burchardt, J. and Sayer, K. (Eds.). 2017. *Transforming the Countryside: The Electrification of Rural Britain*. Abingdon: Routledge.

Brown, J. n.d. *Woollen Textile Mills and Population Growth Demographic Study 1851–1881*. http://galashielshistory.com/index.html.

Burchardt, J. 2007. Agricultural History, Rural History, Or Countryside History? *The Historical Journal* 50(2): 465–481. https://doi.org/10.1017/S0018246X07006152.

Burrell, A. 2011. Renewable Energies from the Rural Sector: The Policy Challenges. Report to OECD.

Carter, I. 1979. *Farm Life in North East Scotland 1840–1914*. Edinburgh: John Donald.

Connolly, K., Allan, G.J. and McIntyre, S.G. 2016. The Evolution of Green Jobs in Scotland: A Hybrid Approach, *Energy Policy* 88: 355–360.

Cook, P., Booth, J., Grieve, J, Roberts, D. and Slee, B. 2016. *The Land-Based Sector in North East Scotland*. A Study for Aberdeenshire, Angus and Moray Councils.

Dawson, P.S. 1950. The Old Mills on the Ericht in Blairgowrie and Rattray. Published privately: available from http://ninetradesofdundee.co.uk/download/mariners_&_seamen/minutes/Blairgowrie Mills.pdf. Accessed August 15, 2019.

Devine, T. 1999. *The Scottish Nation 1700–2000*. Harmondsworth: Penguin.

Economic Development Unit Shetland Islands Council. 2010. *Shetland in Statistics*.

European Environment Agency. 2017. *Perspectives on Transitions to Sustainability*. EEA Research Report no 25, EEA, Copenhagen.

Fenton, A. 1976. *Scottish Country Life*. Edinburgh: John Donald.

Geels, F.W. 2002. Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-level Perspective and a Case-Study. *Research Policy* 31(8–9): 1257–1274.

Geels, F.W. 2005. *Technological Transitions and System Innovations: A Co-Evolutionary and Socio-Technical Analysis.* Cheltenham: Edward Elgar.

Geels, F.W. and Schot, J. 2007. Typology of Sociotechnical Transition Pathways. *Research Policy* 36(3): 399–417.

Geels, F., Sovacool, B.K. and Sorrell, S. 2018. Of Emergence Diffusion and Impact: A Sociotechnical Perspective on Researching Energy Demand. In: Jenkins, K.E.H. and Hopkins, D. (Eds.) *Transitions in Energy Efficiency and Demand*: *The Emergence Diffusion and Impact of Low Carbon Innovation*. London: Routledge.

Haggett, P. 1965. *Locational Analysis in Human Geography*. London: Edward Arnold.

Hain, J., Ault, G., Galloway, S., Cruden, A. and McDonald, J. 2005. Additional Renewable Energy Growth Through Small Scale Community Orientated Energy Policies. *Energy Policy* 33: 1199–1212.

Hargreaves, T., Hielscher, S. and Seyfang, G. 2013. Grassroots Innovations in Community Energy: The Role of Intermediaries in Niche Development. *Global Environmental Change* 23: 868–880.

Harnmeijer, J., Harnmeijer, A. and Loyd, C. 2012. Towards a Global Database of Community-Led Renewable Energy Development. *Regions* 287(3): 16–18.

Harnmeijer, J., Toke, D. and Slee, W. 2018. Community Renewables in the UK—A Clash of Cultures? *International Journal of Technology Intelligence and Planning* 12(1): 99–120.

Land Reform Review Group. 2014. *Land Reform Review Group Final Report—The Land of Scotland and the Common Good*. Edinburgh: Scottish Government.

Liddell, G. 2014. *Scottish North Sea Oil and Gas Industry*. SPICe Report 14/28, Scottish Parliament, Edinburgh.

Mackay, D.I. and Buxton, N.K. 1965. The North of Scotland Economy—A Case for Redevelopment? *Scottish Journal of Political Economy* 12(4): 23–49. https://doi.org/10.1111/j.1467-9485.1965.tb00744.x.

Malm, A. 2013. The Origins of Fossil Capital: From Water to Steam in the British Cotton Industry. *Historical Materialism* 21(1): 15–68.

McCrone, G. 2011. Shetland Shows the Way to Oil Wealth. https://www.scotsman.com/news/gavin-mccrone-shetland-shows-the-way-to-oil-wealth-1-1803090.

McDowell, S. 1975. Coal, Oil and Gas: The Changing Energy Scene in Scotland 1950–1980. In: Chap. 13 of Saville, R. (Ed.) *The Economic Development of Modern Scotland*. Edinburgh: John Donald.

Munday, M., Bristow, G. and Cowell, R. 2011. Wind Farms in Rural Areas: How Far Do Community Benefits from Wind Farms Represent a Local Economic Development Opportunity? *Journal of Rural Studies* 27(1): 1–12.

Murphy, J. and Smith, A. 2013. Understanding Transition-Periphery Dynamics: Renewable Energy in the Highlands and Islands of Scotland. *Environment and Planning A*, *45*(3): 691–709. ISSN 0308-518X 278X.

Nick Forrest Associates Ltd, The Scottish Institute of Sustainable Technology and Black & Veatch Ltd. 2008. *The Scottish Hydropower Resource Study: Final Report to the Scottish Government: August 26th, 2008*. https://www2.gov.scot/resource/doc/917/0064958.pdf.

Oglethorpe, M.K. 2006. *Scottish Collieries*. Edinburgh: RCAHMS.

Okkonen, L. 2008. From Exogenous to Endogenous Development in Scottish Forestry: The Feasibility of Small-Scale Wood Energy Enterprise. *Journal of Environmental Planning and Management* 51(2): 221–232. https://doi.org/10.1080/09640560701864852.

Okkonen, L. and Lehtonen, O. 2016. Socio-economic Impacts of Community Wind Power Projects in Northern Scotland, *Renewable Energy* 85: 826–833.

Payne, P.L. 1985. The Decline of Scotland's Heavy Industries 1945–1983. In: Chap. 3 of Saville, R. (Ed.) *The Economic Development of Modern Scotland*. Edinburgh: John Donald.

Perchard, A. 2013. The Salvation of This District and Far Beyond': Aluminium Production and the Politics of Highland Development. *Northern Scotland* 4(1): 43–65.

Perchard, A. and Mackenzie, N. 2013. Too Much on the Highlands? Recasting the Economic History of the Highlands and Islands. *Northern Scotland* 4(1): 3–22.

Phimister, E. and Roberts, D. 2012. The Role of Ownership in Determining the Rural Economic Benefits of On-Shore Wind Farms. *Journal of Agricultural Economics* 63(2): 331–360.

Riddoch, L. 2013. *Blossom: What Scotland Needs to Flourish*. Edinburgh: Luath Books.

Rip, A. and Kemp, R. 1998. Technological Change. In: Rayner, S. and Malone, E.L. (Eds.) *Human Choices and Climate Change*, Vol. 2. Columbus, OH: Battelle Press.

Saville, R. (Ed.). 1965. *The Economic Development of Modern Scotland, 1950–1980*. Edinburgh: John Donald.

Scottish Energy News. 2018. Scottish Coal Mines Set to Generate Electricity Again with New 'Pumped Storage' Gravity-Driven Turbines, February 7, 2018.

Scottish Government. 2016. *Introducing the Scottish Index of Multiple Deprivation 2016*. Edinburgh: Scottish Government.

Scottish Renewables. 2018. *Renewables in Numbers*. https://scottishrenewables.com/sectors/renewables-in-numbers/

Scottish and Southern Electricity. n.d. *Power from the Glens*. Perth: Scottish and Southern Electricity.

Shamsuzzoha, A.H.M., Grant, A. and Clarke, J. 2012. Implementation of Renewable Energy in Scottish Rural Area: A Social Study. *Renewable and Sustainable Energy Reviews* 16(1): 185–191.

Shaw, J. 1984. *Water Power in Scotland: 1550–1870*. Edinburgh: John Donald.

Sieferle, R.P. 2001. *The Subterranean Forest: Energy Systems and the Industrial Revolution*. Knapwell, Cambridge: The White Horse Press.

Simpson, W. 2011. *Flotta Oil Terminal 10th Anniversary*. https://lurdy.wordpress.com/2011/08/20/flotta-oil-terminal-10th-anniversary/.

Slee, B. 2015. Is There a Case for Community-Based Equity Participation in Scottish On-Shore Wind Energy Production? Gaps in Evidence and Research Needs. *Renewable and Sustainable Energy Reviews* 41: 540–549.

Slee, B. and Harnmeijer, J. 2017. Community Renewables: Balancing Optimism with Reality. In: Chap. 3 of Wood, G. and Baker, K. (Eds.) *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Cham, Switzerland: Palgrave Macmillan.

Slee, B., Wallace, J., Pajot, G., Dunn, S. and Bestwick, M. 2009. *A Scoping Study of the Potential for Micro-Hydro-Power in Aberdeenshire Scotland*. Paper presented at Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29–October 3, 2009.

Smout, T.C. 1969. *A History of the Scottish People, 1560–1830*. London: Collins.

Smout, T.C. 1986. *A Century of the Scottish People 1830–1950*. London: Collins.

Stewart, M. 2003. Using the Woods 1600–1850 (2) Managing for Profit. In: Chap. 5 of Smout, T.C. (Ed.) *People and Woods in Scotland: A History*. Edinburgh: Edinburgh University Press.

Strachan, P.A., Cowell, R., Ellis, G., Sherry-Brennan, F. and Toke, D. 2015. Promoting Community Renewable Energy in a Corporate Energy World. *Sustainable Development* 23(2): 96–109.

Vaughan, A. 2017. North Sea Oil and Gas Sector Losing Thousands of Jobs, Survey Shows. https://www.theguardian.com/business/2017/sep/06/north-sea-oil-gas-jobs-oil-price.

Whatley, C.A. 2000. *Scottish Society, 1707–1830: Beyond Jacobitism, Towards Industrialisation*: Manchester: Manchester University Press.

Withers, C.W.J. 2006. A Nation Transformed: Scotland's Geography 1707–1918. In: Brown, I. (Ed.) *The Edinburgh History of Scottish Literature*, Vol. 2. Edinburgh: Edinburgh University Press.

Wood, E. 2005. *The Hydro Boys: Pioneers of Renewable Energy*. Edinburgh: Luath Press.

Wood, G. 2017a. Large-Scale Renewables: Policy and Practice Under Devolution. In: Wood, G. and Baker, K. (Eds.) *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Cham, Switzerland: Palgrave Macmillan.

Wood, G. 2017b. Trouble on the Horizon? Further Devolution and Renewable Electricity Policy in Scotland. In: Wood, G. and Baker, K. (Eds.) *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Cham, Switzerland: Palgrave Macmillan.

Wrigley, E.A. 2013. Energy and the English Industrial Revolution. *Philosophical Transactions of the Royal Society A* 371: 20110568. https://doi.org/10.1098/rsta.2011.0568.

Part III

Towards a New Agenda?

14

The Long Hello: Energy Governance, Public Participation, and 'Fracking'

John Whitton and Ioan Charnley-Parry

1 Introduction

In this chapter, we discuss the promotion of shale gas as part of a UK energy mix of renewable, fossil fuel and nuclear technologies. This seems to go against international agreements signed by the UK Government and others to reduce global greenhouse gas (GHG) emissions. We frame our discussion in terms of 'Energy Governance' and our own conceptualisation of social sustainability. Whereas the decline of fossil fuels has elicited a key theme of this book as the 'Long Goodbye', our experience in England, UK, has been of rather an emerging interest in and extended 'Hello' to shale gas and the process of unconventional gas recovery—hydraulic fracturing or 'fracking'. Shale gas exploration has the potential to enhance national energy resources and therefore energy security, whilst lowering energy prices and providing a 'cleaner' alternative to coal exploitation, whilst conversely having the potential to degrade and contaminate the environment through industrial activity and waste water leakage and induce seismic activity (Sovacool, 2000, 2014). Hence the impacts of activities associated with hydraulic fracturing and the broad societal benefits of shale gas are contentious and contested.

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In Lancashire, UK, the planning process has so far taken around 8 years. In terms of research positionality, we write as academics of a University based in Preston, Lancashire, in what the Conservative Peer Lord Howell (UK Energy Secretary from 1979 to 1981), memorably referred to in a speech to the House of Lords in 2013 as a "*desolate area*" of the UK (Stacey and Pickard, 2013)—since termed 'the desolate North'—a comparison difficult to make with the range of National Parks, Areas of Outstanding National Beauty and Sites of Special Scientific Interest. We have experienced peaceful protest and road blocks at Preston New Road (near Blackpool), protest outside Preston Town Hall as councillors meet to make planning decisions and industry lobbying in the shale gas county. In October 2018, hydraulic fracturing was carried out in the village of Little Plumpton, Lancashire for the first time since the process was linked to earthquakes in the same area in 2011. This, despite local councillors rejecting the application for shale gas exploration. This activity has again coincided with a series of low magnitude earth tremors that have caused work at the site to cease for short periods of time. The events have been reported widely in the media, generating local and national debate around the environmental implications of hydraulic fracturing.

One of the main findings from our ongoing research is the frequency in which the same or similar issues are raised in public forums relating to energy governance, social justice in decision making and citizen participation, irrespective of the energy source under discussion. We discuss these issues below and present our framework for social sustainability as a tool to enable researchers and communities alike to tackle some of these issues in the context of ongoing energy transitions and their impacts on society. Underpinning our discussion is the assertion that whilst understanding the social dimensions and implications of energy transitions is important, at present it is understudied and insufficiently understood. In order to progress, a deeper understanding of the social implications of energy infrastructural developments in general must be sought (Miller et al., 2013), whereby the complexity of 'societal impacts' is further explored. We argue that deliberative engagement with public stakeholders, local communities and societal groups that are likely to be impacted by energy system change plays a central role in enhancing our understanding of energy transition impacts and impact management itself.

2 Energy Governance and Shale Gas

Energy Governance fundamentally links the problem of anthropogenic climate change and energy transitions associated with decarbonising the economy. New governance structures are required to manage such transitions and their direct consequences—not only for national energy policy institutions and energy industries but for communities that rely on fossil fuel exploration for employment, economic development, regeneration and services. However, running in parallel to the low carbon energy transition is the additional disruption of shale gas and tight oil; seen either as a "*new era of energy abundance*" by observers such as Rex Tillerson the Chairman and CEO of ExxonMobil (Tillerson, 2013), or as a sign that we are entering the "*Era of extreme energy*" (Klare, 2011). Although a complex, multifarious notion, we consider governance in the context of public participation and social justice, contributing to the evolving research on energy justice (Bickerstaff et al., 2013; Sovacool and Cooper, 2013; Sovacool and Dworkin, 2014; Sovacool et al., 2014). Evaluating where injustices occur within this context and what processes exist to remedy these (Jenkins et al., 2016) would seem a sensible definition of our approach to understanding energy justice. We consider how energy systems can or should be governed in a way that contributes towards a fair and just society.

Clearly, for governance to be effective, culture, socio-economics and trust play a role if outcomes are to be considered fair and equitable, particularly in a democracy where citizens expect to participate in influencing government energy decision making or for decisions to reflect their concerns. Beierle (2002) states that fairness in participation is achieved by broad representation and equalisation of participants' power, whilst competence often involves the use of scientific information and technical analysis to settle factual claims. Other authors have disputed this equalisation of participants' power as an ideal not always represented in deliberative practice. van Stokkom (2005) emphasises that deliberative processes to inform policy do not always meet equality and rationality ideals. Behind the ideal of rational dialogue between equal participants the author finds an interplay of power and emotion dynamics that can aid or impede deliberation. Whilst procedural fairness is important, it is also the fairness of outcomes and how they are distributed that truly matters to those impacted by large-scale and/or contentious energy developments and has also been shown to influence societal acceptance (Visschers and Siegrist, 2012). Despite the significance of technological considerations and challenges, the process of unconventional oil and gas exploration is clearly not simply a technological issue (Centner, 2016). We acknowledge that energy-related technological solutions to mitigate against climate change are being seen as a priority due to concerns relating to the sufficient timeliness and extent of societal and economic change (Lee et al., 2012).

In 2014, then UK Prime Minister, David Cameron declared the government was "*going all out for shale*", announcing that cash strapped local authorities would benefit from business rates raised from shale gas sites (Watt, 2014). In the same year, then US President Barack Obama in his State of the Union address publicised natural gas as a transition 'bridge fuel', extolling the virtues of natural gas as a low carbon alternative to coal (Plumer, 2014). Democrats in the US, influenced by Bernie Sanders, later changed their view, incentivising wind and solar power over natural gas (Lin, 2016). The oil and gas industry clearly have hopes beyond transition, hoping that natural gas will play a large role in future energy supply in addition to the development of renewable energy (Bousso and Nasralla, 2018). The UK Government is encouraging shale gas exploration and considers the fuel to be part of a UK energy mix with nuclear and renewables. Either way, the development and extraction of unconventional energy resources from shales, coal beds and tight sands, has become one of the most important global energy policy phenomena of the twenty-first century (Whitton et al., 2018b), which has increased the global supply of hydrocarbons and lowered their price (Van de Graaf, 2017). However, the plentiful supply and demand for hydrocarbons is in stark contrast to international agreements to reduce GHG emissions, such as the Paris Agreement that came into force on 4 November 2016. At the time of writing, 55 Parties were signed up to the Convention, representing around 55% of total global GHG emissions. Despite signatories agreeing to accelerate and intensify the work needed for a sustainable low carbon future, a substantial effort—over and above that agreed—is now required if there is any chance of meeting the target of keeping global warming below 2 degrees Celsius (Rogelj et al., 2016). This and the assertion in October 2018 by the Intergovernmental Panel on Climate Change (IPCC) that limiting global warming to 1.5°C compared to 2°C could go hand in hand with ensuring a more sustainable and equitable society (IPCC, 2018). The report makes it clear that we are already experiencing the adverse effects of 1°C of global warming.

Debates persist on the role of shale gas within a modern energy landscape. Weijermars et al. (2011: 402) assert that until renewable energy technologies mature and are able to produce large quantities of energy to meet demand in an economic manner, gas production from unconventional resources must continue to "*bridge the transition period*". In addition, unconventional gas is considered to hold the potential to reduce dependency on imports, thus enhancing energy security whilst building resilience against "*price shocks and supply interruptions*" (Weijermars et al., 2011: 404). The notion of *time* is worth noting here; a factor that is of central importance in both the climate change and energy transitions debates. Time (as one factor among several) is seen as necessary for renewable technologies to develop and 'mature', but conversely time is an ever-decreasing resource and has a direct impact on whether international emissions reduction targets are to be met or if efforts to prevent a global temperature rise of above 1.5°C (IPCC, 2018) are to be effective in stemming climatic volatility. A conflict exists; time must be allowed for a broad range of renewables (i.e. beyond the notably maturing technologies of solar and onshore wind) to develop and contribute to reducing energy-related emissions, whilst the forecasted window of time in which action against long-term climate mitigation is reducing rapidly. We discuss this later in the chapter. Another important factor in the energy governance narrative is that of societal influence or 'participation', which we discuss below.

3 Participation

There is increasing acknowledgement that public support for energy technologies is not entirely based upon the assumption of public trust in technical expertise and the assurances of developers. We see this theme in our work on energy governance (Whitton et al., 2018a) and that of other authors, such as Anna Szolucha in Lancashire UK and Grabowiec, Poland (Szolucha, 2018), Imogen Rattle, James Van Alstine and Tudor Baker in Lancashire and Yorkshire, UK (Rattle et al., 2018). These authors highlight the public experience of a system of governance, perceived by residents to favour development over their concerns—based on recent events in Lancashire, UK it would seem their concerns are well founded. Conversely, there also exists a degree of long-standing mistrust of 'the public' in the context of "*high level policy discourse*" around the significant technological transitions and transformations required to mitigate severe climate change (Lee et al., 2012: 33). The uncertainty surrounding the impact on local communities, their residents and how they will influence the policy-making process surrounding shale gas has been identified to have produced barriers to the 'pro-fracking' government policy in the UK (Cairney et al., 2015). This has also been the case for wind turbine developments in Ontario, Canada (Christidis et al., 2017), where the authors find that changes to policy and decision-making processes may address opposition.

Public engagement upstream of the decision point for siting controversial technologies is widely discussed (Corner et al., 2012; Wilsdon and Willis, 2004), whereby heterogeneous publics are provided access and resources to engage in processes, by which they may form adequate personal opinions and preferences through informed deliberation and public debate on issues that may affect them. This is increasingly seen as a benchmark for dealing with technology-generated social controversy (Felt and Fochler, 2008; Flynn et al., 2011; Hagendijk and Kallerud, 2003). The concern voiced by these authors, and echoed here, is that there needs to be adequate public engagement in the processes of assessing both the social and ethical feasibility of shale gas as a fuel and a technological solution to energy security, climate change and economic growth (a participatory technology assessment process), and for siting new shale gas installations downstream at the point of siting actual fracking wells. If this is absent, then decision-making will reflect the choices of central, institutional actors rather than those that are directly affected (Kleinman, 2000). By looking across the case studies of other energy technology siting processes, it is clear that to do so would likely lead to public opposition, political controversy and eventual planning failure. The uncertainty of how local communities and impacted residents will influence the policy-making process surrounding shale gas has been identified by some to have produced barriers to the pro-fracking government policy in the UK transforming into a pro-fracking policy outcome (Cairney et al., 2015). Beyond shale gas, scholars such as Lee et al. (2012) observe that despite legal obligations in national, EU and international law to provide opportunities for public participation during consenting processes for nationally significant energy projects, strategic planning policy appears to offer up very little of significance to be discussed and that can be legitimately influenced. The potential for participation to become a frustrating "*bureaucratic hurdle*" (Lee et al., 2012: 33) for stakeholders, whereby legal rights to participate only bear limited opportunities to legitimately influence process (Lee et al., 2012) is an important consideration in the energy transition debate. It is of particular significance given the degree of technological change that is likely required to mitigate climate change.

We have highlighted the US regulatory systems' complexity, heterogeneity, lack of transparency, and limited local voice for US stakeholders previously, whereas we have discussed how in the UK the concept of public engagement has become an institutionalised facet of energy technology development processes (Whitton et al., 2017). However, numerous national case studies point to institutional failures to site controversial energy-related technologies in the absence of sufficient community-level participation in the planning process. So, where and how can the public engage on issues relating to shale gas developments?

4 Incorporating Social Justice Into Energy Infrastructure Decision Making

Energy transitions represent a myriad of transformational shifts within an energy system, which inevitably—directly and indirectly—impact upon societies via changes not only to technologies and the price of energy itself but to the "*broader social and economic assemblages*" associated with the production and consumption of energy (Miller et al., 2013: 135). Energy system change involves the social process, changes and outcomes that may go unnoticed by more analytical approaches. As part of such transformations, decision-making is complex and reactive to changing circumstances and pressures on that system. However, towards the implications of these multi-scalar transformations, energy debates are considered by some to be limited in scope, insufficiently informed, and 'stunted', whereby they underemphasise how and to what degree energy systems impact upon societies whilst little opportunity for societal involvement and influence is available, beyond that of traditional technocratic actors such as engineers and bureaucrats (Miller et al., 2013).

As early as 2007, researchers highlighted that social acceptance was and would continue to be a constraining factor in achieving ambitious government target for the deployment of renewable energy technologies in numerous countries (Wüstenhagen et al., 2007). The authors highlight wind energy as particularly problematic because of visual impact on landscapes. This has indeed proved to be the case—at the time of writing Dumfries and Galloway local councillors formally objected to a 30-turbine wind farm development near Wanlockhead in the Lowther Hills. The decision will now rest with the Scottish Government and the outcome of an 8 day public enquiry in October 2019. The same authors also highlight how the influences on socio-political and community acceptance are increasingly recognised as being important for understanding the contradictions between widespread support for renewable energy and the public objection to projects. The planning process relating to Nationally Significant Infrastructure Projects (NSIPs) has also been the subject of recent academic research by academics at UCL. The UK Research Council study focuses on decision making and participation on large renewable energy developments (UCL, 2017). Previous work conducted by the same authors (Rydin et al., 2015) suggests a strong policy commitment by Government to promoting low carbon energy infrastructure and implies a prior 'in principle' assumption that the proposed development is necessary. Interesting for our work here, is that the authors raise a concern regarding the legitimacy of a process that provides legal provision for citizens to participate, but in a context that may restrict the potential for public concerns and aspirations to influence final regulatory decisions.

We argue that a seldom-considered element of energy transition decision-making is that of fairness—that is socially sustainable decision making. If these decisions are deemed to be unfair by society, they may be perceived as 'unacceptable', face challenge or objection, and potentially fail to achieve broad social acceptance. Social justice, whereby the multifarious impacts on communities (also conceived of as end users, customers, 'the public') are understood, acknowledged and influence process, must play a visible role in energy-related decision-making, particularly when this involves significant 'transition-level' planning and change and if decisions are to be achieve any degree of societal support or acceptance. We have discussed previously in a comparison between the UK and US, how existing systems of energy governance provide insufficient opportunities for substantive engagement (Whitton et al., 2017). According to Thibaut and Walker (1975), it is the belief of citizens that procedures hold importance, because "*fair procedures produce fair outcomes*" (MacCoun, 2005: 182). However, these produce multiple and often unknown outcomes and impacts upon societies, raising concerns surrounding social justice, notions of 'procedural fairness' and 'procedural justice' of the decision-making processes. For project developers, meeting procedural justice ideals with transparent decision making is an important factor in avoiding conflict with local populations (Gross, 2007). In this sense, demonstrable justice and fairness during processes such as participation and decision-making can aid in increasing local support for a project. Where acceptance is not achieved, local opposition often exists, which is economically and socially costly to both developers and communities as it can result in planning delays and a loss of trust (Cotton and Devine-Wright, 2011), of which the latter is notably difficult to retrieve. Rootes (2006) has also shown how the absence of procedural justice can reveal how power relations between local actors may be imbalanced, which has ethical implications for decision-making policy making surrounding nationally significant infrastructure projects (NSIPs). We argue that the absence of demonstrable social justice within shale gas projects will likely lead to societal resistance and opposition, political critique, and the inability to be deemed as positive or 'good'.

As Lebel et al. (2006) state, the central goal of good governance is social justice, whereas Fung (2015) describes social justice as a central value of democratic governance. In short, effective governance requires social justice at its core, and we argue that effective governance is required to achieve any sense of energy justice in relation to shale gas projects. As part of this effective governance, participation that is legally required must also take the form of legitimate engagement with opportunity for deliberative dialogue and for this engagement to result in genuine procedural influence. We wish to avoid the scenario forecasted by Lee et al. (2012), whereby affected communities may grow frustrated and become disillusioned with engagement processes due to their perceived superficial and bureaucratic nature. Rather, we would employ an approach focussed on moving beyond consultation to deliberation and debate, knowledge and experience sharing, learning, and the envisioning of desirable futures. We also respond to the calls of other scholars for improvements to infrastructure-related decision-making through the guarantee of "*social contribution*" and improvements in public methodologies to "*best represent social needs*" (Sierra et al., 2018: 510), thereby increasing decision-making legitimacy and efficacy in the view of public stakeholders. This represents a move towards more socially informed and just energy decision-making as part of effective energy governance.

In the UK, a small number of exploration companies dominate shale gas exploration, one of which is Cuadrilla. Cotton et al. (2014) discuss procedural justice in the context of Cuadrilla's shale gas exploration activities in Lancashire, UK in recent years, concerning community benefit practices and community engagement with locally affected communities. Permitted site licenses which were obtained prior to Cuadrilla's exploration activities did not require Environmental Impact Assessments (EIAs). Due to these activities being exploratory as opposed to commercial, and being declared to cover an area under 1 hectare (Kotsakis, 2012), Cuadrilla's practices complied with the legal regulatory framework (Town and Country Planning Regulations 1999 in England and Wales), but were questionable in regards to their social acceptability. Cotton et al. (2014: 433) observe that by avoiding the EIA, the company's practices avoided generating a Social Licence to Operate (SLO), failing to produce any degree of "*ongoing status of local stakeholder approval*". Howard-Grenville et al. (2008) highlight the importance of SLO due to the unintended consequences for industry, such as conflict, opposition and project delays, that may arise by ignoring or acting contrary to the expectations of local publics. There can also be regulatory consequences if regulatory authorities experience pressure from elected representatives to bridge this social gap and tighten regulatory conditions (Gunningham et al., 2004). As this agreement with communities is not a legal requirement and is intangible, companies and industries may question its value or impact; however, Calvano (2007) has shown that communities surrounding these developments can become sites of social conflict and political contestation. Cotton et al. (2014) note that gaining SLO requires establishing procedural fairness, by engaging communities in decision-making over site licensing, an observation also made by Gross (2007). However, the authors propose that Cuadrilla's communication with communities in Lancashire and Suffolk were insufficiently deliberative, and merely demonstrated 'deliberative speak' (Hindmarsh and Matthews, 2008), communicative rhetoric which fails to ensure that communities are involved in decision-making and establish a SLO.

Recent proposals look to provide local authorities in the UK with monetary incentives, such as 100% business rates for extraction activities, which carry potentially negative implications for the impartiality of these bodies and may damage "*the procedural environmental justice capabilities for councils to protect vulnerable constituents*" (Cotton et al., 2014: 434). At the present time, the recently re-formed Conservative government launched a consultation document on the Shale Wealth Fund (SWF) (see HM Treasury, 2016), which provides details on how additional revenue could be provided to local communities, to populations affected by shale gas development sites, *beyond* funding provided by the shale gas industry (UKOOG, 2016). Funding, incentives and community benefit packages are reported elsewhere as becoming a common characteristic of site selection strategies for other energy industries, such as nuclear, or more specifically nuclear waste management (see Kojo and Richardson, 2014). On the subject of revenues derived from shale gas developments, US-based research conducted by Paydar et al. (2016) explores the association between local public support for Unconventional Gas Development (UGD) (Boudet et al., 2014) and UGD-related public revenues disbursed to county and municipal governments. The authors find a positive correlation between the collection of 'impact fee' revenues and support for UGD projects, and importantly, that higher rates of public support were found to be associated with municipal-level payments than to county-level governments. Such findings have governance implications for the UK, in that it may be more socially acceptable and supported for revenue-based support to 'shale gas communities' to be managed at a more decentralised, local scale, where communities and local institutions have greater influence on how development-related funds are distributed and utilised in their locality.

The notion of locality holds relevance in discussions and decisions around shale gas exploration. Communities that are geographically distant from shale gas sites, and therefore not deemed to be 'associated' or 'local' to shale gas sites but are perceived by some to be 'impacted' by shale gas operations (e.g. by the transport of development-related resources and materials by heavy goods vehicles through or close to these communities) may suffer from this locally-targeted economic governance of 'shale gas benefits'. This has implications for the distributive justice of benefits provision from such developments. Whilst important, participation in decision-making is not enough for 'a just system' to be realised; justice requires both process and distributive aspects to be addressed and fulfilled. In a recent study by Cotton (2016), the author applies an ethical framework for policy evaluation of shale gas in the UK, based on the work of Kristin Shrader-Frechette (Shrader-Frechette, 2002) which considers the interrelationship between the distributive and procedural elements of environmental justice. In applying this framework, Cotton emphasises the argument that government and industry organisations must address both procedural and distributional justice challenges to demonstrate that the decision-making process and outcomes respectively of such developments are ethically legitimate. He also argues that fracking-related planning policy development links to deeper problems of participative and consent-related injustice that relate to ongoing processes of planning reform (the Planning Act 2008, the Localism Act 2011 and now the Infrastructure Act 2015) that shorten decision times across multiple planning consent regimes and remove powers from local communities for decision-making control by rescaling decisions from local to national scales. We contend that this has broader energy justice implications on the shale gas industry and its activities. This highlights again the critical role that time plays in energy-related processes, albeit in a participatory and justice context. We have previously noted the time-based conflict that exists between renewable technology development and climate change-related action. Not only is the diminishing window to act to prevent global temperatures surpassing an increase of 1.5°C creating a barrier to allow for renewable technological maturity, but those same time constraints appear to be contributing to the implementation of policies with limited opportunities for legitimate societal engagement and genuine participation in decision-making. In this sense, the issue of impending climatic changes act both as a driver for the development of lower-carbon energy sources and a barrier to the capacity of decision-making processes for societal involvement and influence. Indeed, time serves as both a predicament for climate-related resolution and for democracy.

How do we respond to what we have identified thus far, and what do we propose in address of such observations? In the context of enhancing governance procedures, we propose that a systemic, participatory, community-led approach is required to achieve any sense of how participation that is procedurally just and fair can be defined, in a community setting and within the context of energy developments. Such an approach incorporates multi-directional dialogue, where local stakeholders are viewed as assets to utilise to improve and legitimise decision outcomes. This in turn contributes towards procedural justice as experienced by affected communities as stakeholders, and more broadly towards the energy justice exhibited by technologically-based development. This is also facilitated by a move away from the technocratic D-A-D approach (Decide Announce Defend) toward the more democratic and collaborative E-D-D approach (Engage Deliberate Decide) of governance and decision-making. Whitton et al. (2015) have previously proposed this type of approach with the aim of achieving a form of legitimacy that allows communities to derive social priorities through 'community visioning'. Community visioning is a process that enables differing viewpoints to be understood through dialogue. Local people come together to identify and debate community values, to highlight both current issues and future opportunities, and then co-develop plans to achieve an agreed vision (Ames, 1997, 2006; Cuthill, 2004). This approach promotes several critical elements, useful within the context of shale gas developments. The first is democracy in shale gas decisions; the manifestation of this being public involvement in energy decisions as part of the dialogue between government, industry and local communities. The second is that the process itself is evidence of a form of procedural justice in shale gas decisions that advances a concept of fairness. In this respect the question asked should be; 'is the process perceived as fair, and is the outcome equitable?' This concurs with the suggested necessities of ethically legitimate decision-making, in both procedural and distributive contexts, as discussed by Cotton (2016).

In terms of process, the approach is community led and asset based (using the skills and resources based in the community), using deliberation to generate community priorities. We aim to initiate a lasting change within communities through building social capital; focusing on community assets not deficits (National Council for Voluntary Organisations (NCVO), 2014). An example of this approach on a national scale is provided by Big Local Trust, the £220m, 15-year UK National Lottery programme to encourage voluntary action and community development to support communities to achieve their own goals. This decentralised governance structure sees funds spent according to the priorities and needs of local communities, as articulated by community members, an approach which we argue can inform the development of a socially just and ethically legitimate system of governance for shale gas developments.

The notion of social justice as part of a system of energy governance is important is energy transitions are to be broadly positive and beneficial to a wide range of stakeholders and community members. As Miller et al. (2013) discuss with regard to the notion of energy justice, energy transformations must be examined in order to identify whether they will or could perpetuate existing or create new negative impacts of energy production and use and thus the ways in which this can be mitigated. Engaging with currently or potentially affected communities can assist in this endeavour to understand how energy transitions and the changes inherent in them may impact them, including whom may be particularly affected and for what reasons. As a point of definition here, Miller (2012: 48) has previously suggested that energy justice encompasses "*choices about what kinds of energy systems to build for the future, where to build them, and how to distribute their benefits, costs, and risks*". With this in mind it is important to seek not only traditional 'expert' views on what these benefits, costs and risks are *likely or expected* to be, but the perspective of those who are to be directly impacted by energy transitions and *experience* how these benefits, costs and risks may manifest and distribute themselves 'on the ground'. In order to ensure that the governance of energy transitions is just and fair, we must do more to understand what would be considered just and fair by those who will now and for many years in the future, within a myriad of different contexts and from a variety of perspectives, such does the complexity of local communities require.

5 Social Sustainability

Infrastructure-related social sustainability is a subject that scholars observe is neglected but emerging as an area of interest (Sierra et al., 2018). It is an area which our work seeks to contribute towards in-part due to the detrimental effects that socially under-informed and inconsiderate planning and decision-making can have on society and the project (Sierra et al., 2018; also see Naderpajouh et al., 2014; Temper et al., 2015), and on fulfilling societal needs and priorities. Engaging in social science research on the subject of hydraulic fracturing and unconventional hydrocarbons is recommended by scholars to increase our capacity to identify potential risks, impacts and implications for society, so that we may effectively assess and gauge the prudency of proceeding with shale gas exploitation (Centner, 2016). More broadly, we argue that further research is required in examining the social sustainability and social impacts of energy transitions in the UK, of which North Sea and shale gas may play a role our transition from coal and imported gas. However, there are clearly renewable alternatives. Both renewable and non-renewable energy sources face opposition to deployment; non renewables due to GHG emissions, statutory nuisance, hazards to health and difficulties with extraction and renewables due to visual impact (e.g. wind) and impacts on the natural environment (e.g. tidal barrage).

We have recommended a process whereby affected or potentially affected public stakeholders can deliberatively and openly discuss project plans and impacts in the context of local contexts (Whitton et al., 2015), and then inform and influence project-related decision-making processes, thus contributing to efforts to address a lack of societal inclusion and social justice. There is insufficient focus on social sustainability in the energy transitions literature, and more research must be conducted in order to identify how social sustainability is represented in different energy transition scenarios and to disparate societal groups who may be impacted. For example, social development and sustainability can often be effectively understood through the exploration of local experiences whereby local context can be discussed in nuanced detail (Karami et al., 2017; Soltani et al., 2015), as opposed to the opinions and predictions of external experts.

This approach echoes calls in the academic literature for energy debates to be "*informed by robust empirical and theoretical inquiries*" (Miller et al., 2013: 136) into how energy transitions will affect social groups. We argue that a crucial aspect of understanding socio-technological systems and the changes they undergo is exploring the experiences of local communities and disparate societal groups through deliberative dialogue, thereby understanding how energy transitions may impact upon social sustainability at the local scale.

We have previously proposed a social sustainability framework for energy infrastructure decisions (Whitton et al., 2015), particularly relevant for the exploration of energy transitions and their societal impacts. Other scholars have similarly called for the development of methodologies that better assess the socio-economic impacts of expanding energy infrastructure and explicit consideration of the long-term impacts of this infrastructure on local communities and economies (e.g. renewable energy infrastructure, Rydin et al., 2018), both being areas which our approach seeks to dialogically explore. We focus on engaging in deliberative dialogue with a number of affected social groups within a locality, exploring what sustainability means to them and how sustainability is perceived, particularly in a social context. From this, sustainability criteria can be co-developed based on the group's social priorities and ranked by importance. These discussions are framed via the introduction of a particular energy technology or energy transition narrative, through which the social sustainability criteria are re-prioritised based on perceived social impacts. Once these criteria are prioritised in the context of social impacts, the approach then seeks to explore with each group the notion of 'desirable futures' involving these discussed technologies or transition examples. Desirable future scenarios are then co-established from these group dialogues, which are used as a basis for reflection and deliberation to establish how these desirable futures can be achieved in a socially sustainable manner. Suffice to say other dimensions of sustainability will naturally be discussed within group dialogue but that the thematic focus is that of social sustainability in an energy context. Through this approach, both local context and the diverse needs and priorities of local communities can be explored and understood within specific energy contexts, whereby findings can inform and influence specific decision-making processes.

6 Conclusion

Our discussion of energy governance and participation when considering the future of shale gas exploration or 'fracking' raises a number of issues, whilst also highlighting areas for future research. A persistent issue is that of transparency and access to planning and decision-making surrounding hydraulic fracturing in the UK and the degree of agency afforded to affected communities. After 8 years of exploration, communities such as those in Lancashire remain concerned about the environmental and social implications of this energy technology. Given recent judicial outcomes allowing fracking to go ahead, communities feel that fair governance is inconsistent with locally made decisions having been overturned by government. Recent earth tremors as a result of exploratory activity in Lancashire have furthered the debate on the environmental justice implications of shale gas exploitation in the UK.

The tension between national energy security, climate change obligations and democracy is one that underlies the shale gas debate but also other energy projects, particularly in the UK where government support nationally often contrasts with an ever-present scepticism and uncertainty among local communities and the wider population. Without adequate, legitimate and timely participation in decision-making, where pre-determined outcomes are avoided, local support for energy developments will experience ongoing stagnation.

Energy development 'without the community' is likely to engender a dearth of community support, whether national energy interests are met or not. In short, opaque and unjust processes will likely lead to unjust and contested outcomes.

In both the US and the UK we have observed a lack of opportunity for local communities to engage in dialogue to influence development outcomes for unconventional energy developments. If shale gas resources are to be explored and exploited, then the complexity, uniqueness and priorities of local communities must also be explored. Unconventional and other large-scale energy projects require more than public consultation. We argue that deliberation, open debate, and early-stage dialogue with a range of social groups is necessary for any form of effective and fair energy governance. We have proposed a framework for exploring both conceptions of local sustainability and perspectives on what a sustainable energy future could include for local communities.

The complexity of energy transition and the associated timeframe for action to meet emission targets and mitigate irreversible global temperature increases suggests that energy system changes will affect society in a myriad of ways and to varying degrees. It is due to this complexity and contentious nature of energy technologies that work is required to examine and understand the unique impact of energy transitions in specific localities. We argue that collaborating with local communities, whereby diverse local needs, experiences and expertise, and priorities are explored is more likely to lead to decisions that are socially sustainable.

Regarding shale gas in particular, the UK Government narrative regarding its commitment to a reduction of CO_2 emissions whilst promoting a shale gas industry is a confusing one. How is this compatible with a just energy transition away from traditional fossil fuels and towards 'cleaner' energy? What role, if any, will shale gas have alongside renewable energy technologies in the UK to aid climate change mitigation efforts, in the context of an ever-decreasing window of opportunity? Indeed, is time rather than technocracy the emerging primary factor in the restriction of deliberative and dialogic opportunity? These areas require further attention and research.

References

Ames, S. 1997. *A Guide to Community Visioning*. Washington, DC: American Planning Association.

Ames, S. 2006. Community Visioning. In: Steiner, F.R. and Butler, K. (Eds.) *Planning and Urban Design Standards*. Hoboken, NJ: Wiley, pp. 39–40.

Beierle, T.C. 2002. The Quality of Stakeholder-Based Decisions. *Risk Analysis* 22(4): 739–749. https://doi.org/10.1111/0272-4332.00065.

Bickerstaff, K., Walker, G. and Bulkeley, H. 2013. *Energy Justice in a Changing Climate: Social Equity and Low-Carbon Energy*. London: Zed Books.

Boudet, H., Clarke, C., Bugden, D., Maibach, E., Roser-Renouf, C. and Leiserowitz, A. 2014. "Fracking" Controversy and Communication: Using National Survey Data to Understand Public Perceptions of Hydraulic Fracturing. *Energy Policy* 65: 57–67. https://doi.org/10.1016/j.enpol.2013.10.017.

Bousso, R. and Nasralla, S. 2018. Natural Gas Here to Stay Beyond Energy Transition, Big Oil Says, October 9, 2018. https://www.cnbc.com/2018/10/09/reuters-america-natural-gas-here-to-stay-beyond-energy-transition-big-oil-says.html

Cairney, P., Fischer, M. and Ingold, K. 2015. *Hydraulic Fracturing Policy in the UK: Coalition, Cooperation and Opposition in the Face of Uncertainty*. Paper presented at the Political Studies Association Annual International Conference, Sheffield, UK. https://www.psa.ac.uk/sites/default/files/conference/papers/2015/Cairney%20Fischer%20Ingold%20fracking%20in%20the%20UK%2025%20Feb%202015.pdf.

Calvano, L. 2007. Multinational Corporations and Local Communities: A Critical Analysis of Conflict. *Journal of Business Ethics* 82(4): 793–805. https://doi.org/10.1007/s10551-007-9593-z.

Centner, T.J. 2016. Observations on Risks, the Social Sciences, and Unconventional Hydrocarbons. *Energy Research and Social Science* 20: 1–7. https://doi.org/10.1016/j.erss.2016.08.007.

Christidis, T., Lewis, G. and Bigelow, P. 2017. Understanding Support and Opposition to Wind Turbine Development in Ontario, Canada and Assessing Possible Steps for Future Development. *Renewable Energy* 112: 93–103. https://doi.org/10.1016/j.renene.2017.05.005.

Corner, A., Pidgeon, N. and Parkhill, K. 2012. Perceptions of Geoengineering: Public Attitudes, Stakeholder Perspectives, and the Challenge of 'Upstream' Engagement. *Wiley Interdisciplinary Reviews: Climate Change* 3(5): 451–466. https://doi.org/10.1002/wcc.176.

Cotton, M. 2016. Fair Fracking? Ethics and Environmental Justice in United Kingdom Shale Gas Policy and Planning. *Local Environment*: 1–18. https://doi.org/10.1080/13549839.2016.1186613.

Cotton, M. and Devine-Wright, P. 2011. NIMBYism and Community Consultation in Electricity Transmission Network Planning. In: Devine-Wright, P. (Ed.) *Renewable Energy and the Public: From NIMBY to Participation*. London: Earthscan.

Cotton, M., Rattle, I. and Van Alstine, J. 2014. Shale Gas Policy in the United Kingdom: An Argumentative Discourse Analysis. *Energy Policy* 73: 427–438. https://doi.org/10.1016/j.enpol.2014.05.031.

Cuthill, M. 2004. Community Visioning: Facilitating Informed Citizen Participation in Local Area Planning on the Gold Coast. *Urban Policy and Research* 22(4): 427–445. https://doi.org/10.1080/0811114042000296335.

Felt, U. and Fochler, M. 2008. The Bottom-Up Meanings of the Concept of Public Participation in Science and Technology. *Science and Public Policy* 35(7): 489–499. https://doi.org/10.3152/030234208X329086.

Flynn, R., Bellaby, P. and Ricci, M. 2011. The Limits of Upstream Engagement in an Emergent Technology: Lay Perceptions of Hydrogen Energy Technologies. In: Devine-Wright, P. (Ed.) *Renewable Energy and the Public: From NIMBY to Participation*. London: Routledge, pp. 245–259.

Fung, A. 2015. Putting the Public Back into Governance: The Challenges of Citizen Participation and Its Future. *Public Administration Review* 75(4): 513–522. https://doi.org/10.1111/puar.12361.

Gross, C. 2007. Community Perspectives of Wind Energy in Australia: The Application of a Justice and Community Fairness Framework to Increase Social Acceptance. *Energy Policy* 35(5): 2727–2736. https://doi.org/10.1016/j.enpol.2006.12.013.

Gunningham, N., Kagan, R.A. and Thornton, D. 2004. Social Licence and Environmental Protection: Why Businesses go Beyond Compliance. *Law and Social Inquiry* 29: 307–341. https://doi.org/10.1111/j.1747-4469.2004.tb00338.x.

Hagendijk, R. and Kallerud, E. (2003). *Changing Practices of Governance in Science and Technology in Europe: A Framework for Analysis. Science Technology and Governance in Europe (STAGE) Discussion Paper*. www.stage-research.net.

Hindmarsh, R. & Matthews, C. 2008. Deliberative Speak at the Turbine Face: Community Engagement, Wind Farms, and Renewable Energy Transitions, in Australia. *Journal of Environmental Policy & Planning* 10(3), 217–232. https://doi.org/10.1080/15239080802242662.

HM Treasury. 2016. *Shale Wealth Fund: Consultation—August 2016*. London: Crown Copyright. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/544241/shale_wealth_fund_final_pdf-a.pdf.

Howard-Grenville, J., Nash, J. and Coglianese, C. 2008. Constructing the License to Operate: Internal Factors and Their Influence on Corporate Environmental Decisions. *Law & Policy* 30(1): 73–107. https://doi.org/10.1111/j.1467-9930.2008.00270.x.

IPCC. 2018. Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by Governments [Press Release]. http://www.ipcc.ch/pdf/session48/pr_181008_P48_spm_en.pdf.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H. & Rehner, R. (2016). Energy Justice: A Conceptual Review. *Energy Research & Social Science* 11: 174–182. https://doi.org/10.1016/j.erss.2015.10.004.

Karami, S., Karami, E., Buys, L. and Drogemuller, R. 2017. System Dynamic Simulation: A New Method in Social Impact Assessment (SIA). *Environmental Impact Assessment Review* 62: 25–34. https://doi.org/10.1016/j.eiar.2016.07.009.

Klare, M.T. (2011). The Era of Xtreme Energy: Life After the Age of Oil, December 6, 2017. https://www.huffingtonpost.com/michael-t-klare/the-era-of-xtreme-energy_b_295304.html?guccounter=1&guce_referrer_us=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_cs=JhuaxrDW0weoMnj6h6h_EA.

Kleinman, D.L. (Ed.) 2000. *Science, Technology and Democracy*. Albany: State University of New York Press.

Kojo, M. and Richardson, P. 2014. The Use of Community Benefits Approaches in the Siting of Nuclear Waste Management Facilities. *Energy Strategy Reviews* 4: 34–42. https://doi.org/10.1016/j.esr.2014.06.004.

Kotsakis, A. 2012. The Regulation of the Technical, Environmental and Health Aspects of Current Exploratory Shale Gas Extraction in the United Kingdom: Initial Lessons for the Future of European Union Energy Policy. *Review of European Community and International Environmental Law* 21(3): 282–290. https://doi.org/10.1007/s10551-007-9593-z.

Lebel, L., Anderies, J.M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T.P. and Wilson, J. 2006. Governance and the Capacity to Manage Resilience in Regional Social-Ecological Systems. *Ecology and Society* 11(1): 19.

Lee, M., Armeni, C., Cendra, J.D., Chaytor, S., Lock, S., Maslin, M., …, Rydin, Y. 2012. Public Participation and Climate Change Infrastructure. *Journal of Environmental Law* 25(1): 33–62. https://doi.org/10.1093/jel/eqs027.

Lin, A. 2016. Natural Gas as a Transition Fuel: A Bridge Too Far? July 7, 2016. https://thebulletin.org/2016/07/natural-gas-as-a-transition-fuel-a-bridge-too-far/.

MacCoun, R.J. 2005. Voice, Control, and Belonging: The Double-Edged Sword of Procedural Fairness. *Annual Review of Law and Social Science* 1(1): 171–201. https://doi.org/10.1146/annurev.lawsocsci.1.041604.115958.

Miller, C.A. 2012. Energy Justice: Ensuring Human Dignity in the Post Carbon Future. *Cairo Review of Global Affairs* 5(May): 46–59.

Miller, C.A., Iles, A. and Jones, C.F. 2013. The Social Dimensions of Energy Transitions. *Science as Culture* 22(2): 135–148. https://doi.org/10.1080/09505431.2013.786989.

Naderpajouh, N., Mahdavi, A., Hastak, M. and Aldrich, D.P. 2014. Modeling Social Opposition to Infrastructure Development. *Journal of Construction Engineering and Management* 140(8), 04014029. https://doi.org/10.1061/(asce)co.1943-7862.0000876.

NCVO. (2014). *Big Local: The Early Years [Evaluation Report]*. http://localtrust.org.uk/assets/downloads/documents/Final_report_reduced.pdf.

Paydar, N.H., Clark, A., Rupp, J.A. and Graham, J.D. 2016. The Effect of Pennsylvania Impact Fee Disbursements on Local Acceptance of Unconventional Gas Development. *Energy Research & Social Science* 20: 31–44. https://doi.org/10.1016/j.erss.2016.04.007.

Plumer, B. 2014. Obama Says Fracking Can Be a 'Bridge' to a Clean-Energy Future. It's Not That Simple. *The Washington Monthly*, January 29, 2014.

Rattle, I., van Alstine, J. and Baker, T. 2018. Shale Gas Development in England: A Tale of Two Mineral Planning Authorities. In: Whitton, J., Cotton, M., Brasier, K and Charnley-Parry, I.M. (Eds.) *Governing Shale Gas: Development, Citizen Participation and Decision Making in the US, Canada, Australia and Europe*. Oxon: Routledge.

Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., … Meinshausen, M. 2016. Paris Agreement Climate Proposals Need a Boost to Keep Warming Well Below 2°C. *Nature* 534: 631. https://doi.org/10.1038/nature18307. https://www.nature.com/articles/nature18307#supplementary-information.

Rootes, C. 2006. 8. Explaining the Outcomes of Campaigns Against Waste Incinerators in England: Community, Ecology, Political Opportunities, and Policy Contexts. In: McCright, A.M. and Clark, T.N. (Eds.), *Community and Ecology*, vol. 10. Emerald Publishing, pp. 179–198.

Rydin, Y., Lee, M. and Lock, S.J. 2015. Public Engagement in Decision-Making on Major Wind Energy Projects. *Journal of Environmental Law* 27(1): 139–150. https://doi.org/10.1093/jel/eqv001.

Rydin, Y., Natarajan, L., Lee, M. and Lock, S. 2018. Do Local Economic Interests Matter When Regulating Nationally Significant Infrastructure? The Case of Renewable Energy Infrastructure Projects. *Local Economy: The Journal of the Local Economy Policy Unit* 33(3): 269–286. https://doi.org/10.1177/0269094218763000.

Shrader-Frechette, K.S. 2002. *Environmental Justice: Creating Equality, Reclaiming Democracy*. Oxford: Oxford University Press.

Sierra, L.A., Yepes, V. and Pellicer, E. 2018. A Review of Multi-criteria Assessment of the Social Sustainability of Infrastructures. *Journal of Cleaner Production* 187: 496–513. https://doi.org/10.1016/j.jclepro.2018.03.022.

Soltani, A., Hewage, K., Reza, B. and Sadiq, R. 2015. Multiple Stakeholders in Multi-criteria Decision-Making in the Context of Municipal Solid Waste Management: A Review. *Waste Manag* 35: 318–328. https://doi.org/10.1016/j.wasman.2014.09.010.

Sovacool, B.K. 2014. Cornucopia or Curse? Reviewing the Costs and Benefits of Shale Gas Hydraulic Fracturing (Fracking). *Renewable and Sustainable Energy Reviews* 37: 249–264. https://doi.org/10.1016/j.rser.2014.04.068.

Sovacool, B.K. and Cooper, C.J. 2013. *The Governance of Energy Megaprojects: Politics, Hubris and Energy Security.* Cheltenham: Edward Elgar Publishing Ltd.

Sovacool, B.K. and Dworkin, M.H. 2014. *Global Energy Justice: Principles, Problems and Practices*. Cambridge: Cambridge University Press.

Sovacool, B.K., Sidorstov, R.V. and Jones, B.R. 2014. *Energy Security, Equality, and Justice*. New York: Routledge.

Stacey, K. and Pickard, J. 2013. Fracking Should Focus on 'Desolate' Northeast, Says Lord Howell—July 30, 2013. https://www.ft.com/content/8faf3c78-f910-11e2-86e1-00144feabdc0.

Szolucha, A. 2018. Assessing Risk from Fracking in the UK and Poland: The Limits of Robust Regulation and Responsible Development. In: Whitton, J., Cotton, M., Brasier, K. and Charnley-Parry, I.M. (Eds.) *Governing Shale Gas: Development, Citizen Participation and Decision Making in the US, Canada, Australia and Europe*. Oxon: Routledge.

Temper, L., del Bene, D. and Martinez-Alier, J. 2015. Mapping the Frontiers and Front Lines of Global Environmental Justice: The EJAtlas. *Journal of Political Ecology 22*: 255–278.

Thibaut, J. and Walker, L. 1975. *Procedural Justice*. Hillsdale, NJ: Erlbaum.

Tillerson, R. 2013. *Capitalizing on the Coming Era of Energy Abundance*. Paper presented at the Address to the Texas Allience of Energy Producers, Houston, Texas, USA (2nd April 2013). https://corporate.exxonmobil.com/news/newsroom/speeches/2013/0402_capitalizing-on-the-coming-era-of-energy-abundance.

UCL. 2017. *Evidence, Publics and Decision Making for Major Wind Infrastructure.* https://www.ucl.ac.uk/nsips/pdfs/Final_Findings_Recommendations.

UKOOG (Producer). 2016. Community Engagement Charter: Oil and Gas from Unconventional Reservoirs, January 17, 2016. http://www.ukoog.org.uk/community/charter.

Van de Graaf, T. 2017. Is OPEC dead? Oil Exporters, the Paris Agreement and the Transition to a Post-carbon World. *Energy Research & Social Science* 23: 182–188. https://doi.org/10.1016/j.erss.2016.10.005.

van Stokkom, B. 2005. Deliberative Group Dynamics: Power, Status and Affect in Interactive Policy Making. *Policy & Politics* 33(3): 387–409. https://doi.org/10.1332/0305573054325701.

Visschers, V.H.M. and Siegrist, M. 2012. Fair play in Energy Policy Decisions: Procedural Fairness, Outcome Fairness and Acceptance of the Decision to Rebuild Nuclear Power Plants. *Energy Policy* 46: 292–300. https://doi.org/10.1016/j.enpol.2012.03.062.

Watt, N. (2014). Fracking in the UK: "We're Going All Out for Shale," Admits Cameron. https://www.theguardian.com/environment/2014/jan/13/shale-gas-fracking-cameron-all-out.

Weijermars, R., Drijkoningen, G., Heimovaara, T.J., Rudolph, E.S.J., Weltje, G.J. and Wolf, K.H.A.A. 2011. Unconventional Gas Research Initiative for Clean Energy Transition in Europe. *Journal of Natural Gas Science and Engineering* 3(2): 402–412. https://doi.org/10.1016/j.jngse.2011.04.002.

Whitton, J., Parry, I.M., Akiyoshi, M. and Lawless, W. 2015. Conceptualizing a Social Sustainability Framework for Energy Infrastructure Decisions. *Energy Research & Social Science* 8: 127–138. https://doi.org/10.1016/j.erss.2015.05.010.

Whitton, J., Brasier, K., Charnley-Parry, I. and Cotton, M. 2017. Shale Gas Governance in the United Kingdom and the United States: Opportunities for Public Participation and the Implications for Social Justice. *Energy Research & Social Science* 26: 11–22. https://doi.org/10.1016/j.erss.2017.01.015.

Whitton, J., Cotton, M., Brasier, K, and Charnley-Parry, I.M. 2018a. *Governing Shale Gas: Development, Citizen Participation and Decision Making in the US, Canada, Australia and Europe*. Oxon: Routledge.

Whitton, J., Cotton, M., Brasier, K, and Charnley-Parry, I.M. 2018b. Introduction: Governing Shale Gas. In: Whitton, J., Cotton, M., Brasier, K and Charnley-Parry, I.M. (Ed.) *Governing Shale Gas: Development, Citizen Participation and Decision Making in the US, Canada, Australia and Europe*. Oxon: Routledge.

Wilsdon, J. and Willis, R. 2004. *See-Through Science: Why Public Engagement Needs to Move Upstream*. London: Demos.

Wüstenhagen, R., Wolsink, M. and Bürer, M.J. 2007. Social Acceptance of Renewable Energy Innovation: An Introduction to the Concept. *Energy Policy* 35(5): 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001.

15

Ban or Regulate? A Critical Juncture in New York's Fossil Fuel Regulation

Ida Dokk Smith

1 Introduction

The transition towards a low-carbon energy system in the United States (US) has been described as a layering process, where existing rules and systems for fossil fuels are left in place, while renewable energy policies are placed on top of the old system (Laird, 2016). The US is not alone in this regard. Leading renewable energy countries in Europe are also phasing in renewable energy while fossil fuel exploration and production continues. Decisions that would indicate a break with the dominant fossil fuel regime, such as removing subsidies or banning production, have so far not been part of national climate policy strategies (Lazarus and van Asselt, 2018). When and why does a government decide to apply restrictive supply-side climate policies?

To address these questions I analyse the political process leading up to the ban on hydraulic fracturing ('fracking') in New York.[1] I draw on a dual-model of institutional change, where institutional development goes through phases

[1] I want to thank the interviewees for taking the time to talk to me and respond to later inquiries. I am particularly grateful to Kate Sinding who first made me interested in this political process during a conversation on renewable energy policy in the state back in 2017.

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starting with a critical juncture followed by a period of institutional reproduction (Pierson, 2000, 2004). In situations when political systems are out of balance and outcomes are undetermined, researchers have to identify key decisions and events influencing those decisions to explain why a political system is steered in a certain direction, selecting one institutional equilibrium over another (Capoccia, 2016). Hence, a critical juncture is a situation of uncertainty "*in which decisions of important actors are causally decisive for the selection of one path of institutional development over other possible paths.*" (Capoccia, 2016: 1)

New York is the only US state with significant shale gas resources that has banned hydraulic fracturing. The policy breaks with the current policy paradigm (Hall, 1993) with the state as facilitator (and benefactor) of natural resource development. The ban also deprives landowners from deciding over their mineral rights. Furthermore, the process coincides with the Obama administration's support for shale gas development as part of a broader US climate policy strategy. In a US context, the case stands out because the state's environmental agency concluded that shale gas development contributes to climate change and can undermine investment in renewable energy.

The oil and gas industry entering New York, eager to start exploration and development, is treated as an external shock that unbalanced the political system. I argue that when the governor decided to ban hydraulic fracturing in 2014, structures had already started to constrain his choices. The key decision traces back to his predecessor, who decided to update the state's environmental guidelines for oil and gas development in 2008. This decision initiated several interrelated positive feedback effects. It follows that political feasibility of restrictive supply-side climate policy is not something we can define with a predefined set of variables. Political feasibility is created through the political process.

This chapter contributes to the emerging literature on hydraulic fracturing (Goldthau, 2018; Weible et al., 2016), which is part of a broader conversation about the role of gas in the transition towards a low-carbon energy system and restrictive supply-side climate policies (Lazarus and van Asselt, 2018). In this chapter, I emphasise strategic interaction within an opposition that can respond by calling for either regulation or a ban. Furthermore, I locate the political process within the broader transition towards a low-carbon energy system. The outcome in New York is not only a ban on hydraulic fracturing. The process exacerbates the state's ongoing orientation towards renewable energy and makes further restrictive supply-side climate policies more likely. After a brief introduction to hydraulic fracturing in the US (Sect. 2), I present my theoretical framework and the method applied (Sects. 3 and 4). Section 5 examines the process leading up to the ban on shale gas development in New York, followed by discussion and conclusion (Sect. 6).

2 Background: Hydraulic Fracturing in the US—Extending the Fossil Fuel Path

In 2017 the US became a net exporter of natural gas, and total net energy imports fell to their lowest level since 1982 (EIA, 2018). The country is also trending towards becoming a net exporter of crude oil (Rapier, 2018). Behind the statistics is a shale revolution enabled through the combination of two technologies, hydraulic fracturing and horizontal drilling. Shale resources are trapped within rocks and sediments, and to access them fossil fuel producers drill vertically down to the shale and then horizontally across the formations containing extractable gas (Wilber, 2012). To extract shale resources, the gas operator utilises natural systems of cracks in shale formations and creates new ones by pumping large quantities of water mixed with sand and chemicals into the well (Wilber, 2012).

These innovations have made it technically feasible to tap into US shale oil and gas resources, one of the largest in the world. Once proven commercially viable in Texas, natural gas producers took the technology to new shale formations in Louisiana, Oklahoma, Colorado and Pennsylvania. Later fossil fuel producers have also yielded oil from hydraulic fracturing. In 2005 the George W. Bush Administration passed the Energy Policy Act, which exempted the industry from the Safe Drinking Water Act, the Clean Air Act and the Clean Water Act. As with other extractive industries in the US hydraulic fracturing is primarily regulated at the state level (Richardson et al., 2013).

While a game changer in the US natural gas market, hydraulic fracturing can be understood as an incremental change advancing the current global fossil fuel regime. On the other hand, the practice has also brought new dynamics to the debate on fossil fuel production. First, drilling activity takes place in the close vicinity to people's homes and communities. In 2013, The Wall Street Journal estimated that 1 in 20 Americans lived less than one mile from a well drilled since 2000 (Gold and McGinty, 2013). Second, this industrialisation of US communities has brought local employment opportunities but also increased concern for public health and environment, including drinking and surface water contamination, air quality and methane leaks (for a review see Weible et al., 2016).

The controversies around hydraulic fracturing are reflected in the academic literature. Policies governing the shale gas industry have been examined from perspectives shedding light on various aspects of the industry's development and societal responses. Scholars have identified two coalitions—local governments and citizens against industry and state policymakers—based on policy belief structures or frames, most recently from a comparative perspective (Lis and Stankiewicz, 2017; Weible et al., 2016). Other scholars view the growth of an anti-fracking movement as part of a broader US climate movement (Cheon and Urpelainen, 2018).

This chapter builds on this literature, motivated by three observations. First, it is not clear where the boundary between a movement and a coalition is drawn. Cheon and Urpelainen (2018) note the inherent conflict within the US environmental community, where some mature environmental non-governmental organisations (ENGOs) have been willing to accept shale gas development under strict regulation. The opposition to hydraulic fracturing has been found to advocate for both ban and regulation (Heikkila et al., 2014a, Weible and Heikkila, 2016), which for instance in the UK has led to the proponents consisting of industry and one ENGO (Cairney et al., 2016).

Furthermore, this tension is related to actors' perception of the role of gas in the transition towards a low-carbon energy system. Thus, the case of unconventional fossil fuel development must be viewed in the larger context of a low-carbon energy transition. Studies of climate policy in the US reflect the literature in general focusing on demand-side policies such as subsidies towards clean technology (Karapin, 2016; Stokes and Breetz, 2018). Empirical studies are needed to determine if or how the policy area of shale gas development is related to the adoption of renewable energy policies.

Finally, hydraulic fracturing can be viewed as a relatively new policy area, particularly knowledge of negative impacts has grown with industry development (Mobbs, 2014). When a policy area is formed, actors can express uncertainty by calling for more research (Sabatier and Jenkins-Smith, 1993). However, hydraulic fracturing also builds on existing vested interest structures. This is important because at the early phase of a policy process actors can achieve competitive advantages (Pierson, 2000) This suggests that scholars should pay particularly attention to the early phase to explain policies governing hydraulic fracturing.

3 Critical Junctures and Institutional Reproduction

In the following I argue that an agency-based account of critical junctures is a useful concept complementing existing literature on hydraulic fracturing, particularly where the practice introduces oil and gas activity in new areas. In such instances the phenomenon studied is institutional formation, meaning "*the various types of political processes through which institutional choices are made: strategic interaction, coalition-building, norm-generation strategies aimed at influencing the perception of the legitimacy of institutional innovations by rule-takes, and choices made by powerful political leaders.*" (Capoccia, 2016: 15)

Historical institutionalists conceptualise critical junctures as "*moments of structural indeterminacy and fluidity during which several options for radical institutional innovation are available*." (Capoccia, 2016: 15) These moments are critical because they give rise to path-dependent processes, processes of institutional development that over time is increasingly difficult to alter due to positive feedback mechanisms (Pierson, 2000).[2]

According to Pierson (2004) there are four key features associated with path-dependent processes. First, multiple outcomes are possible at the initial stage or when the path is created. Second, the starting point can be a relatively minor event. Third, when and in what sequence events occur matters. Early events are more important than later events in explaining an outcome. Fourth, once a policy process is well established, the policy output is likely to remain stable and resist change.

While the critical juncture is central in path-dependent processes as the starting point of a new path, the literature has devoted more time to the phase of institutional reproduction (Capoccia, 2016). In the following I use Capoccia and Kelemen (2007) to present a theory of critical junctures. In addition to defining the critical juncture for institutional analysis, the authors conceptualise the *unit of analysis*, *time horizon*, *near misses* and *power asymmetry and key actors*.

According to Capoccia and Kelemen (2007: 384), critical junctures are "*relatively short periods of time during which there is a substantially heightened probability that agents' choices will affect the outcome of interests*." The definition emphasises that actors at a critical juncture consider more alternatives than normal and that their choices trigger path-dependent processes. Path-dependent processes are results of both key decisions made during critical

[2] Pierson (2004) argues that institutional stability can also result from non-path-dependent causes.

junctures and the mechanisms of institutional reproduction that it initiates (Capoccia and Kelemen, 2007).

Because a critical juncture can represent a critical moment for one institution and not another, scholars have to specify the institution for which the critical juncture is critical (Capoccia and Kelemen, 2007). The *unit of analysis* is normally an institutional setting, for example, public policies, structured interaction between organisations or policy regimes, which constrain actors' decisions during phases of equilibrium (Capoccia and Kelemen, 2007).

Furthermore, scholars have used the concept of critical juncture to explain phases with various lengths. To distinguish critical junctures from gradual change processes, Capoccia and Kelemen (2007) suggest that the *time horizon* of a critical juncture must be brief relative to the path-dependent process it initiates. The longer the phase, the more likely that actors will be constrained by reemerging structures.

A third element of the conceptualisation is that a critical juncture is not defined by the outcome of change: it can be a *near miss*. "*If an institution enters a critical juncture, in which several options are possible, the outcome may involve the restoration of the pre-critical juncture status quo.*" (Capoccia and Kelemen, 2007: 352)

Finally, contrary to the literature that introduced the concept of path dependence, where random events and micro-decisions determine the outcome, political science emphasises *power asymmetry and key actors* during critical junctures. "*Political science studies of critical junctures focus on decisions by influential actors—political leaders, policymakers, bureaucrats, judges—and examine how, during a phase of institutional fluidity, they steer outcomes toward a new equilibrium*." (Capoccia and Kelemen, 2007: 354)

4 Method

This within-case analysis applies process tracing (Bennett and Checkel, 2014). I worked inductively, tracing events backwards from the decision to ban. Process tracing requires that scholars consider whether there are other paths to the same outcome (Bennett and Checkel, 2014). Hence, counterfactual analysis (Lebow, 2010) is an essential part of process tracing. The title of this chapter *Ban or regulate?* underlines the uncertainty in which actors operate. I am particularly interested in identifying decisions or events that could have led the process towards regulation. Process tracing and counterfactual analysis are suggested as particularly suited to study critical junctures (Capoccia and Kelemen, 2007).

The analysis draws on primary and secondary sources, such as official documents, letters, news articles and published research. Semi-structured interviews

(Kvale, 1996) complement document analysis (see the references section). I asked questions about the organisation's role and position on hydraulic fracturing, and key points where the process could have tipped towards regulation. Some of the answers can be triangulated with documents, while for instance strategic decisions made prior to official statements are challenging to verify. To initially sketch out the process I used two blogs, one written by the journalist Tom Wilber and the other by Kate Sinding working for the Natural Resources Defense Council (NRDC).[3] Both wrote regularly about the hydraulic fracturing fight that took place in New York State, and would often refer to the, same for example, events or news article that dominated the debate at a specific time during the process.

5 The Ban on Hydraulic Fracturing in New York

In the following, I examine the political process that led up to the ban on hydraulic fracturing in New York. The first phase of this process started when oil and gas companies began leasing land and ended with the governor's decision to update the state's environmental guidelines for permitting in July 2008. The next two phases illustrate how this decision initiated several interrelated processes unfolding around the environmental review. Institutional stability was first reached with the decision to ban in 2014, in phase four. Table 15.1 sets out a timeline for the New York regulatory and policy process.

5.1 2007–2008 A Near Miss for the Oil and Gas Industry

New York partly sits on the Marcellus Shale, one of the largest natural gas fields in North America (EIA, 2015). The region with the highest potential for shale gas production in the state includes the counties west of the Catskill Mountains bordering Pennsylvania. Shale gas development had already started in Pennsylvania, when gas companies crossed the border to New York in 2007 (Wilber, 2012). Factors such as falling gas price and low quality of the shale have been used to explain weakening political pressure to open up for shale gas development in New York (Weible et al., 2016). However, these factors were of little concern during the early rush for land in the state. Gas prices

[3] Kate Sinding, Senior Attorney and Deputy Director NRDC, from 2009 to 2015 (see: https://www.nrdc.org/experts/kate-sinding) and Tom Wilber, Journalist, from November 2011 to 2015 (see: http://tomwilber.blogspot.com/).

Table 15.1 Timeline New York regulatory and policy process

Date	Key regulatory milestones
2008—February	Department of Environmental Conservation (DEC) received its first high-volume hydraulic fracturing (HVHF) permit application for Marcellus (Town of Erin, Chemung Co).
2008—July	Gov. Paterson signed law (S.8169/A.10526) to streamline the application process for unconventional drilling and ordered the DEC to initiate a formal public process to update the 1992 environmental impact statement (GEIS).
2008—October	DEC issued a draft scope of the updated environmental impact statement (SGEIS). Followed by public scoping meetings in November and December 2008 at six venues in the Southern Tier and Catskills. More than 3,000 written comments received.
2009—February	DEC issued a final scope for the SGEIS detailing the analysis required for a thorough understanding of the potentially significant environmental impacts of horizontal drilling and high-volume hydraulic fracturing.
2009—September	DEC released the draft environmental review (dSGEIS) for public review and comment. DEC held four public hearings in the region and New York City, and received more than 13,000 written comments. Proposal was initially open for public comments until November 30, 2009, deadline extended to December 31, 2009.
2009—December	New York City published scientific impact assessment of hydraulic fracturing in the city's watershed. The report conclude that with current technology, shale gas production presented potential risks to public health.
2010—April	DEC announced it would remove NYC and Syracuse drinking watersheds from the ongoing environmental review process and instead conduct a site-specific review process.
2010—August	The Senate passed bill (SB8129) that formally suspends fracking until May 15, 2011.
2010—November	The Assembly passed the temporarily moratorium (SB8129).
2010—December	Gov. David Paterson vetoed bill (SB812) and instead issued an executive order (Nr.41). No horizontal hydro fracking permits would be issued until a final SGEIS was adopted. DEC ordered to issue a revised dSGEIS by June 1, 2011. This opened up for another round of public comments and instituted a six-month moratorium on high volume hydraulic fracturing.
2011—June	New York State Assembly passed a one-year moratorium (stopped in Senate).
2011—July	DEC announced an advisory board with 12 experts representing ENGOs, industry and lawmakers.

(*continued*)

Table 15.1 (continued)

Date	Key regulatory milestones
2011—September	DEC published revised draft SGEIS for public review ending December 12, 2011. DEC suggested to ban hydraulic fracturing in New York City and Syracuse watershed, reforestation areas, wildlife management areas, and "primary" aquifers. DEC received approximately 67,000 comments and public hearing statements on the revised draft. Final deadline to provide comments January 2012.
2011—October	DEC proposed draft regulations to be considered as part of a comprehensive regulatory program described in the draft SGEIS. The Department received 180,000 comments. On February 27, 2013, the proposed regulations expired under provisions of the State Administrative Procedure Act.
2012—June	The New York Times reported that the Governor's office was working on a plan that would allow shale gas development in limited areas.
2012—June	The Assembly passed a law to evaluate public health impacts associated with hydraulic fracturing (A 10234).
2012—September	DEC requested that Department of Health (DOH) reviewed and assessed the SGEIS and mitigation measures, to advice the DEC whether they were adequate to protect public health.
2012—November	The Governor announced a 90 days extension for DEC to published revised regulation.
2013—February	The Governor allowed the deadline to publish revised regulation to pass.
2013—March	The Assembly passed a two-year moratorium on oil and natural gas drilling permits.
2014—June	The Assembly passed a three-year moratorium on oil and natural gas drilling permits.
2014—December	DOH published their review of the SGEIS and recommended that no hydraulic fracturing should proceed until risk to public health can be determined. Governor Cuomo announced a state-wide ban on hydraulic fracking.
2015—April	DEC issued final environmental impact statement. DEC received over 260,000 public comments on the 2009 draft and the 2011 revised draft and the associated regulatory documents.

were soaring, and corporations secured gas leases on tens of thousands of acres in Broome, Sullivan and Delaware counties.[4] In 2007 leases were signed in Pennsylvania for US$25 per acre and 12.5% royalties in production. One year later, XTO signed the first large leasing contract in New York with leases for US$2,411 per acre and 15% royalties (Wilber, 2012).

Documents indicate that key agencies expected shale gas development to happen. In New York, permits for drilling are reviewed and issued by the

[4] Memo of Opposition to S8169/A10526 (2008). Signed by Catskill Mountainkeeper, The Sierra Club Atlantic Chapter and NRDC. Later also Hudson Riverkeeper, the Wilderness Society and Catskill Citizens for Safe Energy. E-mailed directly to author from Wes Gillingham.

Division of Mineral and Resources within the state's environmental agency, the Department of Environmental Conservation (DEC). Expecting a significant increase in horizontal wells, DEC submitted a spacing bill to the legislature in 2008, supported by the gas industry. The bill would streamline the permitting process and allow them to proceed with hydraulic fracturing.[5] This action was within the mandate of the agency, which was tasked with both developing natural resources and environmental conservation. The duel mandate also led to countervailing views on hydraulic fracturing within the agency (I1). Natural gas development also supported the state's energy goal of increasing in-state resources development. In early 2000, the New York State Energy Research Development Authority (NYSERDA) worked with exploration companies to identify fossil fuel reserves (NYSERDA, 2002). The energy strategy published in 2009 estimated that in-state gas development would represent 11% of the state's need by 2020, up from 5% in 2009 (NYSERDA, 2009).

Two groups of societal actors were activated early on. Although their motivations differed, their action helped slow down the process. Catskill Mountainkeeper and Sierra Club were the first ENGOs to get involved and brought the issue of hydraulic fracturing to the attention of national and state ENGOs (I1, I2). Both had members on the ground who were aware of oil companies working to secure land leases. The second group was farm bureaus. In February 2008, the Sullivan County Farm Bureau and Cornell Cooperative Extension held a forum on gas leasing where 40 people attended. This was also the first place Catskill Mountainkeeper spoke out about the problems publicly.[6] The farm bureaus would become the foundation for landowners mobilising for shale gas development (Wilber, 2012). However, before many farmers and landowners became part of this coalition, the farm bureaus called for improved regulation to protect farmers' interests (I3).

The opposition's early mobilisation must be viewed in a national context. Catskill Mountainkeeper organised four public meetings in early 2008, bringing people from Colorado and Wyoming (and later Pennsylvania) who had already experienced problems caused by hydraulic fracturing in their communities (I3). These people warned of the negative impacts from shale gas production. Similarly, the proponents organised to strengthen their negotiation position based on experience from Pennsylvania. The significant

[5] Spacing bill (S8169/A10526) An act to amend the environmental conservation law, in relation to statewide spacing for oil and gas wells. E-mail directly to author from Assemblywoman Lupardo.

[6] "Time line for Peter Applebome New York Times 2007–2011", E-mailed directly to author from Wes Gillingham.

increase in leasing terms noted above was secured by one such landowner association (Wilber, 2012).

While the political outcome was eventually a full ban on hydraulic fracturing, I find no indication that decision makers or existing ENGOs considered this at that time. Early on there were grassroots organisations that took a strict anti-hydraulic fracturing position. One source traces the first discussion of town bans to a meeting held by Damascus citizens and the Community Environmental Legal Defense Fund in February 2008.[7] However, the established ENGOs initially sought strict regulation of the industry (I1). Confronted with the anti-fracking activists, Natural Resources Defense Council (NRDC) responded that a ban was not politically feasible (I1).[8] NRDC assumed that it would be too difficult to fight off the natural gas industry that offered growth to a region struggling economically, particularly when a downstate Democratic governor had to deliver politically to conservative upstate counties. Furthermore, from a climate perspective NRDC viewed gas as a better alternative to coal. Catskill Mountainkeeper, however, argued that their focus on regulation was more strategic (I3). The organisation did not have enough evidence to call for a ban, and a ban position would make it more difficult to get national ENGOs involved (I3). This organisation is the only one, among the existing ENGOs, that later officially joined the anti-fracking movement.

This position is also reflected in a memo signed by the established ENGOs protesting the spacing bill submitted by DEC.[9] The signatories included both NRDC and Catskill Mountainkeeper, emphasising that they were "*not in opposition to the extraction of natural gas as its value as a transitional fuel is appreciated in the larger context of global warming*."[10] However, they asked the legislature to slow down the process and allow time to develop safeguards to protect the environment. Their early argument was that the state's environmental impact assessment for oil and gas drilling, the 1992 Generic Environmental Impact Assessment (GEIS), specifically mentioned that the cumulative impacts of hydraulic fracturing had not been assessed (I3). They

[7] "Time line for Peter Applebome New York Times 2007–2011", E-mailed directly to author from Wes Gillingham.

[8] NRDC, one of the largest US environmental organisations, was founded in New York and its headquarters is in New York City. Interviewees describe the organisation as the most politically influential ENGO in the state.

[9] Catskill Citizens for safe energy, Catskill Mountainkeeper, Riverkeeper, NRDC, Sierra Club Atlantic Chapter and Wilderness society.

[10] Memo of Opposition to S8169/A10526 (2008). Signed by Catskill Mountainkeeper, The Sierra Club Atlantic Chapter and NRDC. Later also Hudson Riverkeeper, the Wilderness Society and Catskill Citizens for Safe Energy. E-mailed directly to author from Wes Gillingham.

did not have to go into technicalities but could point out flaws in existing regulation (I3).

With the environmental agency behind it, the spacing bill received little opposition in the legislature.[11] However, the governor required an update of the environmental impact statement upon signing. He specifically mentioned concerns raised by residents regarding environmental impacts of wide-scale drilling and a town hall meeting that his deputy secretary for the environment attended to gain additional insight into these concerns.[12] Wilber (2012) describes how a handful of people around the governor, including his top environmental advisor and DEC commissioner, were influential in this decision. In addition, I find that the existing ENGOs played an important role in building the case and pressing the governor's office for updating the environmental impact assessment (I1, I3). In 2008 the industry also expressed support for the decision. They expected to move forward on completion of the environmental impact assessment in 2009 (Wilber, 2012). Hence, there was little political cost to argue that the new practice had to be thoroughly analysed and regulated before being deployed.

5.2 2008–2010: The Start of a Movement

Over the next two years, hydraulic fracturing turned into the highest-profiled environmental issue in the state, with deeply conflicting views among opponents and proponents. When the public review process for the draft environmental impact assessment ended in December 2009, the environmental agency had received over 13,000 comments, which they would spend the next year reviewing. However, pressure to start the review process all over again was building.

Even before the public review process ended, 26 organisations signed a letter to the governor calling for the draft study to be withdrawn and to place a one-year moratorium on drilling.[13] While these organisations differed in their

[11] Assembly vote yes: 135 no: 7; Senate vote aye: 45, nay: 16. Spacing bill (S8169/A10526).

[12] Approval memorandum No. 17 Chapter 376, filed with Senate Bill Number 8169-A. E-mailed directly to author from Assemblywoman Lupardo.

[13] Letter to Governor Paterson, December 3, 2009. Signed by Advocates for Springfield, Binghamton Regional Sustainability Council, Catskill Citizens for Safe Energy, Catskill Mountainkeeper, Citizens Campaign for the Environment, Community Environment Defence Council, Concerned Citizens of Otego, Croton Watershed Clean Water Coalition, Damascus Citizens for Sustainability, Delaware Riverkeeper Network, Earth Day New York, Earthjustice, Earthworks Oil and Gas Accountability Project, Environmental Advocats of New York, League of Women Voters of New York, National Wildlife Federation, NRDC, New York Public Interest Research Group, New Yorkers for Sustainable Energy Solutions Statewide, Northeast Organix Farming Association of New York, NYH20 Otsego 2000,

position on hydraulic fracturing, representing both the mature ENGOs and grassroots organisations, they all agreed that the environmental impact study did not adequately evaluate risks from hydraulic fracturing. An online petition calling for the withdrawal of the study received almost 10,500 signatures (Toxics Targeting, 2009). The environmental community also united with state legislators. At a press conference in January 2010, the New York City (NYC), county, state and federal legislators called for a revised environmental review.[14]

This massive mobilisation was coupled with the entrance of a politically powerful stakeholder, NYC, which risked gas production within its watershed. According to Catskill Mountainkeeper, the environmental community actively sought to mobilise the city (I3). The first hearing on gas drilling in the city's watershed was held as early as September 2008.[15] The NYC Department of Environmental Protection (NYCDEP) commissioned an independent scientific assessment published in December 2009, which concluded that hydraulic fracturing would threaten drinking water for nine million New Yorkers (NYCDEP, 2009). The issue seems to be treated as politically toxic among the proponents. During the investigation, Chesapeake Energy Corporation already announced it would not develop its leases within the city's watershed (Mouawad and Krauss, 2009).

The city's early mobilisation gave the opposition more knowledge about potential impacts associated with hydraulic fracturing (I3). Furthermore, it sparked new grassroots mobilisation in Upstate New York. Once citizens realised that NYC wanted to protect their water, they started to ask why they were not allowed to protect their own wells (I3, I2). The upstate-downstate dynamic that tends to divide the state politically, had instead turned into a rallying point (I2).

Increasing concern among citizens and their representatives was reflected in a number of laws on hydraulic fracturing introduced in the legislature.[16] In summer/fall 2010, a one-year moratorium to give the legislature more time to understand the impacts of this new practice passed both the Assembly and Senate. In retrospect, the bill was important because from 2011 to 2014 Republicans controlled the Senate, preventing any legislation on hydraulic

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Riverkeeper, Shaleshock Citizens Action Alliance, Sierra Club Atlantic Chapter, Sustainable Otsego, Theodore Gordon Flyfishers. E-mailed directly to author from NRDC.

[14] Press release Catskill Mountainkeeper: NY Legislators Join Environmentalists To Tell Governor Patterson That the DSGEIS For Horizontal Gas Drilling In The Marcellus Shale Is Deeply Flawed, January 4, 2010.

[15] "Time line for Peter Applebome New York Times 2007–2011", E-mailed directly to author from Wes Gillingham.

[16] For the 2007–2008 term, one bill was introduced, for 2009–2010 it was 18. See: https://nyassembly.gov.leg. Search 'hydraulic fracturing'.

fracturing to pass. Contrary to the opposition's call to sign the bill, the governor vetoed it and issued an executive order.[17] He removed conventional drilling, which the initial bill included, and directed DEC to revise the environmental review study and publish a new draft by June 1st 2011.

The decision opened another round of public comments and placed a *de facto* moratorium on hydraulic fracturing until the completion of the environmental review. By now the industry was not supportive, while it was clear that the governor's party supported a more careful approach. That DEC removed NYC from the ongoing review process also undermined the legitimacy of the first draft. Furthermore, the decision followed the same logic as the previous one, where a sound review process would guide decision-making. According to the governor, most stakeholders "*agree that an objective, science-based analysis is the best approach to setting new policy*."[18]

The development from 2008 to 2010 suggested that the 2008 decision to update the environmental agency's permitting guidelines set in motion a set of interrelated processes, which constrained further policy decisions on hydraulic fracturing in the state. First, the environmental review process formally structured the process. Public trust in the integrity of the review process was low, which would lead to an expansion of the scope. Second, the environmental review process served as an educational platform: "*It gave us a hook to start talking about the issues and the impacts that would affect people*." (I3) More and more negative impacts were uncovered, further strengthening the anti-fracking movement. Finally, slowing down the process gave the opposition time to mobilise (I1, I2, I4) and also unite with established ENGOs despite different philosophies for how to influence policy.

5.3 2011–2012: New Governor, Same Process?

In the previous section I argued that the decision to conduct an environmental review that would govern permits for hydraulic drilling set in motion several processes that increased the political cost of moving forward with drilling. Once Governor Cuomo was inaugurated in January 2011, was he already constrained by his predecessor's choices? Essentially, was the following process one of gradual change or a set of critical decisions? The governor had

[17] Executive order Nr 41: Requiring Further Environmental Review of High-Volume Hydraulic Fracturing in the Marcellus Shale. Signed by Governor Paterson December 13, 2010.
[18] Ibid.

campaigned on economic revival in Upstate New York, which made farmers believe he supported shale gas development (Rahim, 2018). Economic benefits from drilling in Pennsylvania also spilled into bordering counties, including a service center opened by Schlumberger in Chemung County (Navarro, 2011). However, Governor Cuomo also followed his predecessors on climate policy (Karapin, 2016) and his environmental agenda combined economic growth and renewable energy development.

There is no indication that the governor wanted to abandon the review process altogether; such a step would also have been legally challenged (I1). Instead, decisions made under the new governor's administration indicate that there were attempts to find compromises that would allow the process to move forward. Against the recommendation made by more than 40 environmental, public health, conservation, and government representatives to allow sufficient time for the study, he required the environmental agency to finalise the environmental review process. This revised draft put in place several new protective measures but also found less land disturbance with this drilling technique. At the same time, DEC announced an advisory board with experts from ENGOs, industry and policymakers. DEC Commissioner Joe Martens said the panel would make recommendations "*to ensure DEC and other agencies are enabled to properly oversee, monitor and enforce high-volume hydraulic fracturing activities*."[19] At this point Catskill Mountainkeeper publicly adopted a ban position as they saw the review process as a political position to allow the state to move forward (I3). The ENGO was one of the co-founders of the anti-fracking movement's umbrella organisation, New Yorkers Against Fracking, formed in 2012 (Hauter, 2016).

Finally, while DEC reviewed comments, the governor's office was also working on a plan that would allow shale gas development in limited areas. The plan was published by The New York Times in June 2012 (Hakim, 2012). Interviewees pointed out this situation as a critical moment where the industry could have gotten a foot in the door because the opposition appeared split on the issue (I1, I3).[20] NRDC had argued in their comments to the draft environmental review that DEC failed to consider alternatives to full build-out and exemplified with a pilot program. Although the news article did not specifically relate the governor's pilot program to NRDCs plan, the anti-fracking community viewed this as NRDC giving the green light for produc-

[19] Press release DEC: DEC Commissioner appoints members to hydraulic fracturing advisory panel. July 1, 2011. E-mailed directly to author from DEC Office of Media Relations.

[20] I have not been able to identify the other actors that supported a pilot program. However, another academic study identified two groups among both the proponents and opponents that supported permits in some regions on New York (see Heikkila et al. (2014b).

tion in limited areas (I1). NRDC issued an immediate response stating that the organisation did not support any development until the environmental review process was completed (I1). Wilber describes on his blog different stakeholders response. Also, the industry discredited the plan, if hydraulic fracturing was found to be safe it should not be geographically restricted. A few days after, Cuomo denied that the plan had ever existed.[21]

Instead of shifting path, the key decision made under Governor Cuomo would strengthen the existing one. Since the early focus on water contamination, the types of risks reviewed had grown to include radioactivity, methane leakages, socio-economic impacts and increasingly public health. In September 2012, environmental commissioner Martens asked the state's health commissioner to assess the risk hydraulic fracturing posed to public health and his agency's measures to mitigate them. According to the press release, the commissioner's motivation was to ensure a thorough review process and a legally defensible review: "*The review will also ensure the strongest possible legal position for the Department given the near certainty of litigation, whether the Department permits hydrofracking or not*".[22] The pressure for such a health review came from the environmental community and health experts within the anti-fracking movement. In addition to the united front against the pilot program, the call for a health impact assessment was another moment where the ENGOs and the anti-fracking community coordinated their campaigns (I1). As noted by Wilber on his blog, at this time mixed signals also came from within the government. While the department of minerals and resources at DEC found hydraulic fracturing to be safe, the organisation that represented local health departments in the state did not (NYSACHO (New York State Association of County Health Officials), 2012).[23]

Once initiated, a series of new requests and decisions followed. The health review was well received but also criticised by health experts for its scope and process.[24] Similarly, three letters sent fall 2012 to the commissioners of environment and health showed an increasing number of environmental organisa-

[21] Tom Wilber's blog (http://tomwilber.blogspot.com/2012/06/new-york-fracking-trial-balloon-quickly.html).

[22] Press release DEC: Commissioner Martens Rejects Call for "Independent" Health Study of High Volume Hydraulic Fracturing Announces State Health Commissioner to Assess Health Impacts, September 30, 2012. E-mailed directly to author from DEC Office of Media Relations.

[23] Around this time there are also debates about potentially too close ties between the mineral and resource unit within DEC and the industry. See Tom Wilber's blog (http://tomwilber.blogspot.com/2012/07/is-decs-top-regulator-too-close-to-big.html).

[24] Letter to Governor Cuomo October 4, 2012, Concerned health professionals NY https://concerned-healthny.org/letters-to-governor-cuomo/. Accessed March 5, 2019.

tions demanding public participation.[25] The timeline for the study was also under scrutiny. DEC was under pressure to see it finished because state law required that revised regulation be published within 365 days after the public hearings. The governor extended the deadline two months and then allowed the rulemaking deadline to lapse. The decision was made after the health commissioner wrote to DEC in February 2013 that his department needed more time. By now the review process overlapped with the campaign cycle, and stakeholders including the industry did not expect any decision before the election (Passut, 2014).

5.4 2014–2017: Making a Ban Politically Feasible

Only weeks after the gubernatorial election, the governor announced that the health review would be published by the end of the year. The health study concluded that there were significant public risks associated with hydraulic fracturing. In December, after almost six years of environmental review, Governor Cuomo announced that he would ban hydraulic fracturing. His decision was backed by the environmental and health review. The health commissioner left no doubt on these findings, announcing that he would not allow his kids to play close to a fracking site (Kaplan, 2014).

Many forces came together to explain the outcome. I will here focus on information the governor had in 2014 that suggested that the context of this decision had changed sufficiently since his predecessor's decision to update the environmental guidelines. First, the election result showed that the governor lost upstate support to the Republican candidate but also to a Democratic candidate further to the left in the primary. Hence, while the governor might have initially supported development, he was pulled to the left by forces within his own party (Rahim, 2018).

Second, in June 2014 the New York State's Court of Appeal ruled that municipalities had the right to use zoning codes to ban hydraulic fracturing. During the environmental review process, a massive mobilisation at the local

[25] "Letter to Commissioner Shah and Martens" October 5, 2012 Signed by NRDC and Riverkeeper, "Letter to Commissioner Shah and Martens" November 21, 2012 Signed by NRDC, Riverkeeper and Waterkeeper Alliance, "Letter to Commissioner Shah and Martens" December 28, 1012 Signed by Adirondack Mountain Club, Catskill Mountainkeeper, Citizens Campaign for the Environment, Common Cause NY, Delaware Riverkeeper Network, Earthjustice, Earthworks Oil and Gas Accountability Project, Environment New York, Environmental Advocates of New York, NRDC, Riverkeeper, Inc. Sierra Club Atlantic Chapter, Waterkeeper Alliance, Working Families Party. E-mailed directly to author from NRDC.

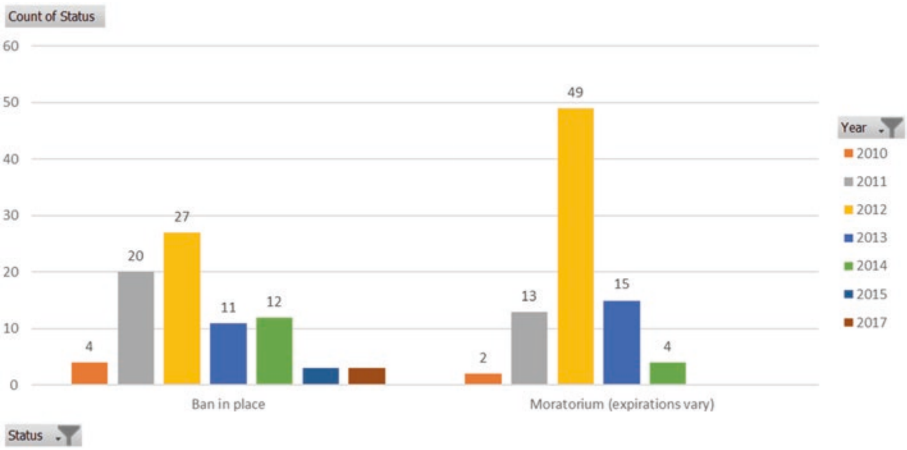

Fig. 15.1 Municipalities and towns with ban or moratorium. (Source: Raw data obtained from FrackTracker, 2019)

level took place. From 2010 to 2017, over 160 local bans or moratoria were implemented among municipalities, peaking in 2012 (Fig. 15.1). The legal statutes of these local policies were however challenged in 2011, when a company sued to overturn the town of Dryden's ban. At that time two-thirds of the city's land was leased (I4). The final environmental review statement specifically mentions the 2014 court ruling and how it changed the economic prospects for shale gas development.

Finally, over the years polls showed a slight increase in opposition to hydraulic fracturing, but one could still argue that the public was divided 50–50 (I1). However, NRDC, now advocating for a long-term moratorium, noted that these polls only asked respondents for or against. They commissioned their own poll and asked specifically about a long-term moratorium. The result showed surprisingly strong support for a ban, as well as strong bipartisan support for a long-term moratorium across the state (I1).

In retrospect one could argue that it had come to a point where a ban was not only political feasible but also in the governor's interest to do so. Contrary to the early decision that started the policy process, the governor's options at this point had expanded to include a ban. However, at the time the governor announced his decision the opponents, including the anti-fracking community, hoped for a long-term moratorium (I1). After the court of appeal's decision, the environmental community feared that the governor would approve shale gas development on the ground that the right to choose should be equal for both communities that banned and those that supported it (LeBrun, 2014). In fact, all the interviewees explain how they did not believe the ban to be political feasible until the moment it was announced. Also individual landowners signed leases almost up to the ban, indicating that they too believed that production would at some point start (I3).

The decision to ban breaks the path-dependent process that supported continued environmental review. It was the decision to ban, and not this process, that brought the system back to institutional equilibrium. The process started out as one concerned about the regulatory regime for fossil fuel production but became a question about the identity of the state (I6). The process described here shows how liberal values became organised and subsequently institutionalised with the ban.

It is also likely that the ban will remain. Since the ban, many landowners in Upstate New York have terminated their leases with support from local lawyers (I4). Furthermore, in 2015, the environmental agency issued their final, legally binding finding statement. If the state wanted to open up for shale gas development, this would require the review process to start over (I2). Recently the industry allowed the deadline to challenge DECs decision to pass without filing a lawsuit.

6 Discussion and Conclusion

6.1 Analysing a Critical Juncture

The time period analysed here is described as a critical juncture, a time of great uncertainty, where decision makers could choose between two paths. I suggest that there are two decisions that stand out: the decision to review the state's environmental impact assessment in 2008 and the decision to ban in 2014. Decisions made during this time period strengthened several of the positive feedback mechanisms set in motion from 2008. They also led to a deepening of the conflict. It is first with the decision to ban that the political system was brought back to equilibrium.

A ban is a point decision, a single yes/no decision that "*allocate a scarce resource to one of a number of actual or potential rivals*" (Anderson, 1981). The decision to update the environmental review that would guide permitting was critical because it changed the formal rules for how this allocation would take place (and how to define the scarce resource). From then on, the opposition protected the status quo. The united call that emerged was that the proponents had to prove that hydraulic fracturing was safe before shale gas development could start. The burden of evidence was placed on the proponents.

The review process also structured the relationship between stakeholders. For example, the environmental agency was required to respond to each comment submitted, independent of the respondent's background. It facilitated a public debate emphasising the incomplete knowledge that existed on hydraulic fracturing and the many risks that were difficult to regulate away. This is different from other places, like Poland, where the risk framing held by local actors and civil society organisations were excluded from the political debate (Lis and Stankiewicz, 2017). In New York, the principle of public participation and the role of environmental organisations was already institutionalised with the adoption of the state's Environmental Quality Review Act in 1975 (Karapin, 2016).

The decision in 2008 marked a *de facto* moratorium that would last until 2014. Had it not, evidence suggests that companies would have started exploration and development in 2008/2009. This was a *near miss* for the oil and gas industry. At that time the industry had the support from the key division within DEC and got a bill through the legislature that would have accelerated the process. It is assumed here that once companies have assets on the ground their stakes are higher and hence political pressure increases. Furthermore, there are positive feedback effects between drilling and infrastructure development, for example pipelines. Hence, once the industry is established, different processes are set in motion that can lead to further production. This is a different argument than pointing to a relatively small fossil fuel industry as a structural factor that increases the political feasibility of a ban. Here I explain why the industry never got their foot in the door in the first place.

While the decision to update the environmental permitting guidelines is key to understand the dynamics that followed, it was not given that a review process would stop industry development in New York. Until the drop-in gas prices in 2012 energy companies were preparing for industry development, and leasing took place up until the ban. It is not sufficient to explain the reason for why the environmental review took place; we also need to look at how it was conducted. Importantly, the ENGOs had the internal expertise to participate in the environmental review process and to build the record needed for the governor to justify his decision (I1). In addition to providing comments to the environmental review, they also used their influence to press for an extended review time, public participation and formal public hearings. Furthermore, the environmental review process was under massive public attention. In total, DEC received over 260,000 public comments on the two environmental review drafts and associated regulatory documents, an unprecedented number in the agency's history.

To explain the ban I have argued that the decision-making environment changed. Contrary to the theoretical perspective that emphasises the role of decision makers in key positions, this is also a case where the aggregate of the many actions and decisions made by activists and citizens was essential. I argue that the decision in 2014 stood between a ban or limited production, while in 2008 the options were environmental review or shale gas production. This is significant; what has taken place over the course of the review process is the mobilisation of an opposition that expanded their win-set (Putnam, 1988).

From the advocacy coalition framework a social movement can be understood as a dynamic contextual event which creates windows of opportunities for the coalition within a particular policy area (Sabatier and Jenkins-Smith, 1993). In this case however, there was not an existing coalition that sought a ban. Instead, it is a situation where the existing ENGOs as well as decision makers were pulled from a more center position to the left, and where relationships were built between grassroots activists and mature ENGOs within a structure that allowed this to happen. The process never came to the point where these two sides had to split. Within the structure of the environmental review process they developed a coordinated approach both in their response to the pilot program and the health impact assessment.

Thus, the analysis recognises the importance of the grassroots movement which over time changed the decision-making environment.[26] Yet, I have paid particular attention to the existing ENGOs, because if they had supported any form of production with regulation this would have undermined the anti-fracking movement. Furthermore, I have focused on the governor's decisions. His decisions both directly, for example by vetoing a spacing bill and ordering an environmental review process, and indirectly, through the election of commissioners, impacted the process. The key role held by the governor was also partly a result of the grassroots campaign, which targeted him directly.

6.2 A Return to Status Quo?

A path-dependent process starts with a critical juncture, goes through a process of institutional reproduction, before being replaced by new processes (Pierson, 2000). In this case I have argued that the decision to ban stopped many of the positive feedback effects set in motion from 2008. The environmental review process itself did not lead to an institutional stable outcome, the ban did. Furthermore, as I will argue here the ban did not return the political system back to the status quo. Instead it has accelerated the transition towards a renewable energy system in the state. Critical junctures are most easily identified in retrospect, so here I can only indicate why the time period

[26] The scope of this study explores the political process at the state level. A full explanation for the mobilisation of the anti-fracking movement is out-with the scope of this chapter.

2008–2014 can itself be viewed as a critical moment for the transition towards a renewable energy system, a process that can take many decades (Grubler et al., 2016).

The most direct link between the ban on hydraulic fracturing and renewable energy can be found at the societal level. Anti-fracking activists see renewable energy as the ultimate solution. New Yorkers for Clean Power, an ongoing campaign in the state, came directly out of the anti-fracking fight, bringing together anti-fracking organisations and renewable energy interests (I1). However, the link is not entirely positive. There is also overlap between those that mobilise against hydraulic fracturing and those that mobilise against industrial wind (I1). The zoning law that was successful in blocking shale gas development can also be used to stymie renewable energy development.

Furthermore, one could argue that even without Governor Paterson's decision to update the environmental guidelines, we would have witnessed local bans on hydraulic fracturing similar to elsewhere in the US. Governor Cuomo's decision stands out because it guarantees that no shale gas development will take place, also in areas that were supportive. Shortly after he ordered the ban on hydraulic fracturing, Governor Cuomo announced the 76West competition with a goal of fostering clean energy businesses in the region that energy producers viewed to have the best shale gas reserves. Renewable energy investments in this region continue to be highlighted by the governor's administration (I5).

The connection between hydraulic fracturing and renewable energy can also be found in public documents. The state's energy plan from 2015, contrary to the one from 2009, does not mention any development of the state's fossil fuel reserves. In addition, the final environmental review statement specifically mentions the state's greenhouse gas emission targets and how cheap gas could undermine the state's renewable energy programs. Note that these documents were written after Governor Cuomo announced the state's clean energy goals and might reflect these clean energy goals rather than being part of a larger climate strategy. The environmental agency's division for climate change informed they were little involved in the decision to ban.[27]

In addition to the link to renewable energy development, the mobilisation against hydraulic fracturing has led to increased mobilisation against fossil fuel infrastructure in general. The anti-fracking community started fighting against gas infrastructure as part of the process to ban hydraulic fracturing, on the ground that such infrastructure continues to create demand for natural

[27] Personal e-mail with the Office of Climate Change, DEC.

gas and put more pressure on production (I1). The pushback against fossil fuel infrastructure projects has continued after the ban and the state has made several decisions that stymied natural gas projects.[28]

6.3 Final Remarks

This case explains the mobilisation for and adoption of a restrictive supply-side climate policy due to local environmental impacts and health concerns. It suggests that avoiding lock-ins and stranded assets, while an indirect effect of such policies, are not arguments for why this policy was adopted in the first place.[29]

There is no indication that the decision to ban hydraulic fracturing in New York was anchored in any broader climate policy strategy. New Yorkers continue to enjoy imported gas from unconventional shale gas for heating and cooking but the state has also lately made major commitments to develop renewable energy. In 2019 Governor Cuomo released a plan to generate 100% of New York's energy from renewable sources by 2040. Since the ban on hydraulic fracturing the state has also banned other fossil fuel infrastructure projects. Future research on restrictive supply-side climate policy could examine whether or not the use of such climate policy tools becomes more likely once it is first applied.

Furthermore, in New York, the ban stopped any further institutional capacity building on fossil fuel regulation at the environmental agency. However, DEC operated under a duel mandate that allowed the agency to both permit and develop natural resources and protect the environment. Strategies for how to deal with such dual policy objectives within regulatory agencies is another area that could be addressed within the emerging literature on restrictive supply-side climate policies.

I have argued that it is important to locate the case within the broader development of shale gas in the US. It mattered that NY was not the first state, as negative impacts in other communities spilled into the debate, and the process unfolded along with an increasing number of scientific studies. Scholars could turn this around, studying if and how the ban in New York influences policy development in other states.

[28] In 2015 Governor Cuomo rejected the plan to build a port for liquified natural gas outside of New York City, and in 2016, DEC denied a pipeline construction company the necessary water permit needed to construct a natural gaspipeline from Pennsylvania to New York.

[29] Assuming that we succeed in meeting global agreed climate goals.

References

Anderson, D.D. 1981. *Regulatory Politics and Electric Utilities: A Case Study in Political Economy*. Boston, MA: Auburn House.

Bennett, A. and Checkel, J.T. 2014. Process Tracing: From Metaphor to Analytic Tool. In: *Strategies for Social Inquiry*. Cambridge: Cambridge University Press.

Cairney, P., Fischer, M. and Ingold, K. 2016. Hydraulic Fracturing Policy in the United Kingdom: Coalition, Cooperation, and Opposition in the Face of Uncertainty. In: Weible, C.M., Heikkila, T., Ingold, K. and Fischer, H. (Eds.) *Policy Debates on Hydraulic Fracturing: Comparing Coalition Politics in North America and Europe*. New York: Palgrave Macmillan.

Capoccia, G. 2016. Critical Junctures. In: Fioretos O, Falleti T.G. and Sheingate A. (Eds.) *The Oxford Handbook of Historical Institutionalism*. Oxford University Press.

Capoccia, G. and Kelemen, R.D. 2007. The Study of Critical Junctures: Theory, Narrative, and Counterfactuals in Historical Institutionalism. *World Politics* 59: 341–369.

Cheon, A. and Urpelainen, J. 2018. *Activism and the Fossil Fuel Industry*. Oxton and New York: Routledge.

EIA (US Environmental Information Administration). 2015. *Top 100 US Oil and Gas Fields*. Washington, DC: US Energy Information Administration.

EIA (US Environmental Information Administration). 2018. *US Net Energy Imports in 2017 Fall to Their Lowest Levels Since 1982*. https://www.eia.gov/todayinenergy/detail.php?id=35532

FrackTracker. 2019. National Datasets. https://www.fractracker.org/.

Gold, R. and McGinty, T. 2013. Energy Boom Puts Wells in America's Backyards. *The Wall Street Journal*.

Goldthau, A. 2018. *The Politics of Shale Gas in Eastern Europe; Energy Security, Contested Technologies and the Social Licence to Frack*. Cambridge: Cambridge University Press.

Grubler, A., Wilson, C. and Nemet, G. 2016. Apples, Oranges, and Consistent Comparisons of the Temporal Dynamics of Energy Transitions. *Energy Research & Social Science* 22: 18–25.

Hakim, D. 2012. Cuomo Proposal Would Restrict Gas Drilling to a Struggling Area. *The New York Times*.

Hall, P.A. 1993. Policy Paradigms, Social Learning, and the State: The Case of Economic Policymaking in Britain. *Comparative Politics* 25: 275–296.

Hauter, W. 2016. *Frackopoly: The Battle for the Future of Energy and the Environment*. New York: The New Press.

Heikkila, T., Pierce, J.J., Gallaher, S., Kagan, J., Crow, D.A. and Weible, C.M. 2014a. Understanding a Period of Policy Change: The Case of Hydraulic Fracturing Disclosure Policy in Colorado. *Review of Policy Research* 31: 65–87.

Heikkila, T., Weible, C.M. and Pierce, J.J. 2014b. Exploring the Policy Narratives and Politics of Hydraulic Fracturing in New York. In: Jones, M.D., Shanahan,

E.A. and McBeth, M.K. (Eds.) *The Science of Stories: Applications of the Narrative Policy Framework in Public Policy Analysis*. New York: Palgrave Macmillan.
Kaplan, T. 2014. Citing Health Risks, Cuomo Ban Fracking in New York State. *The New York Times*.
Karapin, R. 2016. *Political Opportunities for Climate Policy: California, New York, and the Federal Government*. New York: Cambridge University Press.
Kvale, S. 1996. *Interviews: An Introduction to Qualitative Research Interviewing*. Thousand Oaks, CA: Sage.
Laird, F.N. 2016. Avoiding Transitions, Layering Change: The Evolution of American Energy Policy. In: Hager, C. and Stefes, C.H. (Eds.) *Germany's Energy Transition: A Comparative Perspective.* New York: Palgrave Macmillan US, 111–131.
Lazarus, M. and van Asselt, H.J.C.C. 2018. Fossil Fuel Supply and Climate Policy: Exploring the Road Less Taken. Climate Change, Special Issue: Fossil Fuel Supply and Climate Policy. *Stockholm Environment Institute* 150: 1–13.
Lebow, R.N. 2010. *Counterfactuals and Foreign Policy Analysis*. Oxford University Press.
LeBrun, F. 2014. Fracking Ruling a Victory for All. *Timesunion*.
Lis, A. and Stankiewicz, P. 2017. Framing Shale Gas for Policy-Making in Poland. *Journal of Environmental Policy & Planning* 19: 53–71.
Mobbs, P. 2014. Shale Gas and Public Health—The Whitewash Exposed, May 6, 2014. *The Ecologist*.
Mouawad, J. and Krauss, C. 2009. Gas Company Won't Drill in New York Watershed. *The New York Times*.
Navarro, M. 2011. With Gas Drilling Next Door, County in New York Gets an Economic Lift. *The New York Times*.
NYCDEP. 2009. *Final Impact Assessment Report: Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed*. New York: Department of Environmental Protection.
NYSACHO. 2012. NYSACHO Report To High-Volume Hydraulic Fracturing Advisory Panel of New York State Department of Environmental Conservation New York State Association of County Health Officials.
NYSERDA. 2002. New York State Energy Plan 2002. New York State Energy Research and Development Authority.
NYSERDA. 2009. New York State Energy Plan 2009. New York State Energy Research and Development Authority.
Passut, C. 2014. NY State Senator: Fracking Possible After November Election. *NGI Shale Daily*.
Pierson, P. 2000. Not Just What, But When: Timing and Sequence in Political Processes. *Studies in American Political Development* 14: 72–92.
Pierson, P. 2004. *Politics in Time*. Princeton: Princeton University Press.
Putnam, R.D. 1988. Diplomacy and Domestic Politics: The Logic of Two-Level Games. *International Organisation* 42: 427–460.
Rahim, S. 2018. In N.Y., Farmers Think about What Might Have Been. *E&E News*.
Rapier, R. 2018. No, The U.S. Is Not a Net Exporter of Crude Oil. *Forbes*, December 9.

Richardson, N., Gottlieb, M., Krupnick, A. and Wiseman, H. 2013. *The State of State Shale Gas Regulation*. Washington, DC: Resources for the Future.

Sabatier, P.A. and Jenkins-Smith, H.C. 1993. *Policy Change and Learning: An Advocacy Coalition Approach*. Boulder, CO: Westview Press.

Stokes, Leah C. and Breetz, Hanna L. 2018. Politics in the U.S. Energy Transition: Case Studies of Solar, Wind, Biofuels and Electric Vehicles Policy. *Energy Policy,* 113: 76–86.

Toxics Targeting. 2009. *Coalition Letter Requesting Governor Paterson to Withdraw the Department of Environmental Conservation's Draft Supplemental Generic Environmental Impact Statement (dSGEIS) for Oil and Gas Mining*. http://www.toxicstargeting.com/MarcellusShale/coalition_letter.

Weible, C.M. and Heikkila, T. 2016. Comparing the Politics of Hydraulic Fracturing in New York, Colorado, and Texas. *Review of Policy Research* 33(3): 232–250.

Weible, C.M., Heikkila, T., Ingold, K. and Fischer, H. (Eds.). 2016. *Policy Debates on Hydraulic Fracturing: Comparing Coalition Politics in North America and Europe*. New York: Palgrave Macmillan.

Wilber, T. 2012. *Under the Surface: Fracking, Fortunes, and the Fate of the Marcellus Shale*. New York: Cornell University Press.

Interviewees December 2018/January 2019

I1: Kate Sinding (Senior Attorny and Deputy Director NRDC to 2015)

I2: Katherine Nadeau (Policy Director and Water and Natural Resources Director for Environmental Advocates to 2015)

I3: Wes Gillingham (Program Director Catskill Mountainkeeper)

I4: Deborah Goldberg (Managing Attorney Earthjustice)

I5: Tim Woodcock (Field manager Clean Water Action 2008–2010. The Solutions Project 2011–2012)

I6: Assemblywoman Donna A. Lupardo

16

Regulation and Market Reform: The Essential Foundations for a Renewable Future

Iain Wright

1 Introduction

When considering a country's progress in developing its renewable energy resources, it is easy to home into a discussion of Megawatts (MW) of renewable capacity installed each year and whether it is on course to deliver any treaty or government-mandated target. However, understanding the progress of renewable deployment involves much more than tracking installed capacity and checking for official policy support and requires an assessment of the legal, regulatory and economic framework within which new capacity is being, or will be, delivered. This is key to understanding both the degree of success that current achievements represent and the sustainability of further, planned capacity expansion.

This chapter looks at some of the challenges facing power systems as they transition to renewables. It examines the influence of regulation, competition, and generation economics on the viability of investment in the power sector generally and of renewables in particular. Successful deployment and sustainable expansion of renewable generation is much more likely in a market in which these factors are actively addressed. By way of illustration, the chapter includes case studies of two very different markets: the United States (US) and Russian Federation (RF). Though starting from materially different backgrounds, the relative success of renewable capacity delivery in these two

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markets has only been achieved following implementation of reforms that address the same economic and regulatory issues.

Whist an understanding of basic power system economics is fundamental to policy development, having a realistic appreciation of the costs involved during initial stages of the renewable transition is also important. Factors such as dispatchability of renewable technologies, capacity redundancy, infrastructure provision and services to drive system flexibility must also be actively addressed if system reliability is to be maintained and capacity substitution facilitated rather than being duplicated. Some discussion of these factors has been included, although their deployment will be more useful as qualitative measures of renewable market development, as the precise mix of these measures will vary for each market.

2 The Pre-renewables Age

The world into which renewable generation is expanding is very different from that into which the electricity system was being rolled out in the early part of the twentieth century. At that time, larger and more efficient generation units were being built close to their source of fuel, with the consequent requirement for transmission infrastructure to transport the power to where it was to be used. This expansion of capacity took place into a, literally, greenfield environment, in parallel with growing, first time demand from end users. By the mid-twentieth century, economists such as Boiteux (1949) had begun to tackle issues of power system economic efficiency in an environment in which investment costs were high, asset lives comparatively long and the risk of stranded investment as a result of future technical progress (Boiteux, 1957) was very real. Work in this area of pricing was important for understanding how the industry's revenue adequacy could be assured without constraining the overall objective of developing and maintaining a co-ordinated system based on a plant mix that approximated to an economically optimal power system over time.

Of course a monopoly ownership model, whether public, mutual or investor-owned, was useful in ensuring that total required revenue could be collected. Importantly, Boiteux's analysis did consider the stranding of assets, even though this was from the perspective of technological obsolescence, rather than competitive loss of market share. In transitioning to a renewable generation model, it will be seen that stranding of conventional assets remains an important issue to be addressed if an adverse impact of premature closure of incumbent, fossil-fuelled assets on system reliability is to be avoided.

In contrast to the initial power system rollout, the environment into which renewable technologies began to be introduced in the last decades of the twentieth century was one of relative stability and established reliability. Electricity demand was being met in an economically efficient manner, network infrastructure had been established and environmental issues were an area of somewhat niche interest. Where arrangements that allowed the development of renewable generation were established, the motivation appears to have been more about an ideological desire to introduce competition into a monopoly industry than to facilitate the introduction of renewable generation. For example, even though it included specific provisions addressing hydro-electric and combined heat and power generators, legislation for electricity market reform in the United Kingdom (UK) was primarily targeted at the introduction of competition. Indeed, the Energy Act of 1983 described itself as, "*An Act to amend the law- relating to electricity so as to facilitate the generation and, supply of electricity by persons other than Electricity Boards*" (UK Government, 1983).

This policy change was a first step towards opening the monopoly door to allow competition, but arrangements were still defined in terms of the impact of competing generators on the incumbent 'owners' of the market. A more significant consequence of the pricing provisions in this legislation was that it allowed money to 'leak out' of the monopoly system. For as long as the competitive market sector remained small, this issue could safely be ignored, if indeed it was considered at all. But with the passage of time, the issue of revenue adequacy has been found relevant to consideration of generation market contestability and economics well beyond Boiteux's early concerns over stranded investment.

3 Catalysts and Constraints on Renewable Rollout

When evaluating delivery of environmentally-motivated renewable generation in any market, it would be a mistake just to try and map progress onto a template based on the experience of other markets that are much further along the road to implementation. While there are certainly areas of valid comparison, it must also be recognised that many renewable technologies, wind in particular, have advanced significantly since the turn of the twenty-first century. At that time, network operators were facing a steep learning curve in managing significantly more volatile generation systems, as were regulatory authorities who had to make difficult decisions balancing complex technical and market issues while pursuing environmental policy goals. However, these challenges were very much of their time and typical of the kind of issues faced when pioneering a new market or product and should not arise again, even in markets at an early-stage in their renewable development. It is nevertheless interesting to look at some important European policy developments that encouraged, sometimes indirectly, the development of renewable generation and also obstacles that emerged to constrain early adopting markets.

An early step in electricity market liberalisation in the European Community (now the European Union, or EU) was the 1996 Directive (96/92/EC), on common rules for the internal market in electricity. This Directive set out rules for Member States to establish common rules for the generation, transmission and distribution of electricity, including access to the market, as part of the EU internal market implementation process. This policy direction was driven by a desire to benefit customers through competition, rather than with the objective of promoting renewable generation, although it did allow that Member States, "[may] *give priority to generating installations using renewable energy sources*" (European Community, 1996).

Following appropriate transposition by Member States, this Directive guaranteed renewable and other developers non-discriminatory access to markets. But it was only with the passing of the first renewable electricity Directive (2001/77/EC) (European Community, 2001) that explicit renewable energy targets were set for Member States in response to commitments made under the Kyoto agreement. By the transposition deadline, in October 2003, renewable developers in the EU were theoretically able to rely on supportive government policies to deliver increasing amounts of renewable capacity.

Notwithstanding this supportive EU legislative foundation, renewable developers in Ireland experienced a significant shock in December 2003, when technical concerns raised by the system operator brought the renewables development industry to a shuddering halt. In the five-year period to 2003, the Irish system had connected 159 MW of wind capacity, in addition to 30.5 MW connected in the previous five years, to 1997 (Ó Gallachóir, 2004). However, with a total of just under 230 MW of wind generation connected to the system and a further 1,295 MW either committed or progressing through the connection offer process, the system operator, Eirgrid, was becoming concerned at the potential system impact of this rapidly-increasing renewable technology.

For several reasons the issues faced by Eirgrid in 2003 were unprecedented. Understandably the introduction of a significant cohort of a relatively immature, non-dispatchable and non-synchronous generation technology, to a relatively small electricity system of only 7,000 MW, with a relatively small number of conventional thermal units and limited interconnection, was perceived to represent a material risk to system security and stability. Eirgrid had three principal concerns: the lack of specific Grid Code provisions to enforce appropriate standards on windfarm operators; the lack of reliable data from wind generators preventing it from making reliable output forecasts; and the lack of manufacturer-provided computer models to use for assessment of wind turbine behaviour on the dynamic electricity system. On the basis of these technical concerns, the system operator requested that the regulator impose a moratorium on the issue of any further connection offers and in December 2003, the regulator agreed.

However, whilst the regulator accepted the request, primarily out of concern for system security and stability, its decision also highlighted an additional concern, that:

> *Wider policy considerations, such as the economic impact on conventional generation of increased wind penetration have been ignored for the purpose of this direction. In the longer run this has to be a concern.* (Commission for Energy Regulation, 2004: para. 17)

A final point worth noting about the regulator's decision is that it also highlighted the importance of reaching a decision that respected Government energy policy, including the State's international obligations such as those set out in the previously-mentioned Renewable Energy Sources Directive (2001/77/EC).

Once the Grid Code and modelling issues were resolved, the connection moratorium was lifted and Eirgrid embraced the challenge of managing a system with high penetration of variable-output generation. Indeed, it has become a world leader in this area currently allowing an instantaneous level of 65% of non-synchronous generation on the system, with the aim of raising this to 75%, over time. Within the system operator community, there is therefore plenty of technical expertise to guide any individual operator facing these kinds of technical issue for the first time.

4 Relevance of Early Renewable Experience to Current Markets

The above brief overview of experience in Ireland and Great Britain, both prior and subsequent to establishment of the broader European legal framework for renewables, shows how renewables emerged almost as a by-product of reforming traditional (i.e. mainly fossil thermal) electricity markets. Legal and regulatory reform of the industry initially focused on facilitation of competition, rather than with the aim of promoting renewable generation. However, the concurrent development of renewable policy makes it hard to establish whether it was market reform or renewable generation obligations on governments that drove delivery.

A further complication is the remuneration arrangements for generation market entrants in the early stages of market reform. In Great Britain, payments to independent producers under the 1983 Act were based on incumbents' avoided costs whilst, in Ireland, various support schemes in place during the market structural reforms offered renewable developers particular incentives.

Whilst these early market experiences and observations offer some clues as to factors that may support renewable generation deployment, there are too many intertwined strands of change in play to offer any useful framework for the assessment of progress and sustainability of renewable deployment in other markets almost two decades later. Clearly a supportive legal, regulatory, technical and financial environment must be in place for a sustainable renewable generation sector to emerge, but a more robust theoretical underpinning is required to direct effective policy intervention and facilitate meaningful comparisons of progress across markets in a more technologically mature era. However, this does not mean that the degree of market maturity has no relevance to understanding progress with renewable development. Rather, continuing success with renewable rollout depends on timely deployment of the type of technical solutions leading system operators are implementing to manage high penetrations of particular renewable technologies on their networks. But what are these technology issues and what preparatory steps towards mitigation should be evident in a successfully maturing renewable market?

5 Non-MW Characteristics of Renewable Generation

Renewable generation is often referred to in broad terms, as though it were a homogenous technology, such as thermal or nuclear. However, this type of thinking obscures the diversity of proven and developing renewable generation technologies, including offshore wind, hydro, solar photovoltaic (PV), tidal and wave. The development of time-shifting energy storage technologies, such as battery, compressed air, hydrolysis and of course long-proven pumped storage, is essential for increasing system flexibility and thereby maximising renewable generation deployment. So there is a strong argument for monitoring deployment of storage capacity and the introduction of similar system services targeting increased flexibility when considering the sustainability of expansion plans for renewable generation in markets where significant renewable generation capacity has already been deployed.

Conventional, fossil-fuelled generation technologies have only limited dependence on geographical factors. Proximity to a coalfield and source of cooling water were important during the initial development of thermal-based interconnected power systems, when the transmission system was being developed to suit generation deployment. For the subsequent generation of gas-fired plants, proximity to a pipeline and existing grid connection guided location decisions. However, renewable generation depends on, for example, the conversion of utilisable tidal flows, or availability of reliable wind or high levels of rainfall. Climate, topography and geography are therefore fundamentally important to the deployment of renewables and in this respect, expansion of the sector is more complex than merely deciding to add additional production capacity to an existing system, as would have been the case with earlier, conventional generation technologies.

For this reason, a renewables-based power system expansion will generally consist of geographically-distributed generation units, often with low individual capacities compared with fossil-fuelled facilities, whereas a conventional system would normally consist of a relatively small number of high capacity units. Of course, such generalisations ignore significant exceptions, for example China's Three Gorges hydro-electric scheme is designed for an installed capacity of 22.5 GW (Renewables Now, 2012); large for a single generation facility of any technology. Nevertheless, this smaller distributed versus large centralised conceptualisation offers a useful perspective from which to gauge the level of actual commitment that relevant authorities have towards implementation of their renewable generation policies. In terms of access to grid connection policies and investment in network systems, those supporting renewable generation are likely to be significantly different from those required for conventional systems. So a willingness to sanction relevant infrastructure investment is often a more relevant indicator of commitment to renewable generation than a published policy.

Another feature of many renewable generation technologies is that they are often variable in output or must-run because of inability to store their input energy (e.g. run-of-river hydro, or wind generation). They may also have awkward electrical characteristics, such as being non-synchronous, that can present significant technical challenges to the system operator controlling the grid in real time. On the other hand, dispatchable renewable generation has significant advantages over thermal plant in that it can ramp output up or down extremely quickly, which is important for grid stability when there is a significant amount of non-synchronous, variable-output renewable plant on the system.

In summary, any review comparing renewable generation development across jurisdictions needs to look at more than past, present and planned 'Megawatts in the ground'. Where substantial progress has already been made, the question must be whether there is evidence of sustainability in plans for ongoing expansion of renewable capacity. For example, is there evidence of increasing energy storage capacity? Do current or planned market rules require greater resilience in response to rapid changes in system frequency? Are ongoing network enhancements that facilitate further distributed generation underway and planned?

In markets where renewable deployment is at an earlier stage, it is reasonable to look for evidence of resource assessments being undertaken, proven regulatory and revenue support frameworks being implemented, along with appropriate infrastructure development policies. Without these it would be unwise to conclude that renewable development plans will actually be delivered.

This chapter looks at the deployment of renewable energy in the US and Russia, using non-Megawatt parameters of this type to assess the extent to which past performance may serve as a guide to the future.

6 Economics, Contestability, Reliability and Regulation—Key Parameters for Renewables Generation System Economics

6.1 Economics

A detailed exposition of the economics of electricity generation is beyond the scope of this chapter. However, an appreciation of some basic issues of generation economics is important when trying to understand why some states are more successful than others in delivering their renewable goals. In this context, it is instructive to step back and look first at how economics were a relatively minor consideration for the historic, monopoly-owned, thermal plant systems from which, to a greater or lesser extent current, competitive arrangements have evolved. This simple starting point permits greater clarity for exposition of the underlying economic principles of power generation than a more complex model, involving diversity of ownership and competitively-driven stranded investment. This approach is also helpful as it highlights four intrinsic characteristics of electricity generation, that:

- it is capital intensive;
- assets are long-lasting;
- production must continuously match demand that varies significantly, both diurnally and seasonally; and
- real-world production plant is prone to sudden breakdown.

As with any investment, generation investment must be paid for even if it is not always in use and production technology may evolve faster than the life of generation assets. Thus, even if a power system is optimally structured in terms of technologies, capital investment and fuel costs at some moment in time, within an asset lifetime of 30–40 years, it is reasonable to expect some disruption to emerge that invalidates, or at least affects, one or more of these parameters.

However, when the electricity production system is monopoly-owned, whether by the state or by investors, the economic objective has been to develop a system that minimises overall production costs, and hence the cost to customers, by optimising investment in capacity by plant type, operating hours for each generation unit and outturn marginal cost of production for the system as a whole. This type of traditional approach to decisions on generation investment was described by Turvey (1968) in his essay on the application of welfare economics to pricing and investment in electricity supply. For the monopolist, there is no economic regret when technology cost or fuel cost outturns diverge from forecast, because prices can always be adjusted to recoup outturn input costs and un-amortised, stranded investment costs can also be recovered through retail tariffs. A monopoly market is therefore always revenue-adequate.

Perhaps the two most significant factors leading to the demise of such 'economically optimal' monopoly generation systems were the development of efficient combined-cycle gas turbines, that were around 50% more fuel-efficient than existing coal and oil plant, and political shifts that allowed, and even encouraged, independent generators to compete with the monopoly incumbents. The gas technology innovation could have co-existed with a centrally-planned system in which the obsolescence of older coal plants could have been managed without compromising revenue adequacy of the overall system. Tariff increases would have been used to cover stranded costs. But, in combination with market liberalisation allowing equality of access to the grid and, at least in theory, uncontrolled expansion of capacity, the link between system capacity requirement, electricity prices and overall system funding was lost.

The new, competitive environment also removed any incentive for co-ordination of capacity provision between baseload, mid-merit and peaking plant. Experience of the early competitive market in Great Britain showed that developers appeared to discount any material impact of their new capacity on market price and generally planned for maximum power output of their new plants for the maximum duration consistent with a proper maintenance regime. Essentially, revenue maximisation was the goal, with revenue depending on the unit operating, thereby providing a natural hedge for its offtake contract, and a market price below the plant's marginal cost of production during outages; planned or otherwise.

In a competitive market therefore, there is no natural way of recovering even legitimate stranded costs, without recourse to out-of-market mechanisms. Stranding is seen as a normal business risk to be borne by the investor, even for relatively new plant. For example, an investor building an oil-fired generator in the 1970s and completing it just as oil prices increased permanently, by an order of magnitude, would have found operation of the facility to be wholly uneconomic and the facility fit only to be mothballed. If such a scenario had occurred in a competitive market, the owner of the new generation plant would have suffered a total loss, without any means of recompense for such an unforeseeable event. Competitive markets involving large upfront investment costs are therefore more exposed to disruptive change, creating a disincentive to investment in new capacity without some form of price guarantee.

Investment in renewable generation faces a similar type of technology risk. Not so much from a disruptive technology type, but rather from increased scale and declining capital cost of similar technology. For example, the capital cost of a wind generation plant has decreased significantly over the last decade or two, encouraging sufficient market entry to affect the market price of energy for earlier developers. Successful implementation of a renewable generation policy must recognise the need for investors to have some level of revenue certainty over a significant proportion of their assets' useful lives, to minimise their asset financing costs. Without some form of revenue support to mitigate revenue risk within the finance repayment timescale, it is unlikely that renewable developers will be willing to invest.

6.2 Contestability

Bearing in mind that generation plant is long-lived and expensive and that, over time, plant efficiency and reliability decline, there is a natural incentive on investors to seek to maximise their revenue in the early years following commissioning, before unhedgeable assumptions in their investment model cease to hold true and the introduction of newer plant displaces their plant down the merit order. In a competitive market, all generators will therefore bid their output in a manner that optimises their revenue. To understand what that means in practice, the most useful approach is to adopt the principles set out by Baumol et al. (1982) in their groundbreaking work on contestability.

In terms of electricity generation, Baumol, Panzar and Willig's key findings for a contestable market were that:

- A market is contestable if it "*is accessible to potential entrants and … the potential entrant can, without restriction, serve the same market demands and use the same productive techniques as those available to the incumbent firms*" and "*potential entrants evaluate the profitability of entry at the incumbent firms' pre-entry prices. That is, although the potential entrants recognise that an expansion of industry outputs leads to lower prices … the entrants nevertheless assume that if they undercut incumbents' prices they can sell as much of the corresponding good as the quantity demanded by the market at their own prices*" (Page 5).
- '*the quantities demanded by the market at the prices in question must equal the sum of the outputs of all the firms in the configuration … the prices must yield to each active firm revenues that are no less than the cost of producing its outputs. And, … there must be no opportunities for entry that appear profitable to potential entrants who regard the prices of the incumbent firms as fixed*' (Page 5).
- Sunk costs have a significant role in determining whether or not a market is contestable. Where the cost of market entry is reversible without cost, unsustainable prices will provide incentives for rational entrepreneurs to enter the market, as the ability for costless reversal of entry allows temporary profits to be taken at the initial prices of incumbents.
- '*… a sharp increase in the degree of approximation to competitive behaviour can be expected in a contestable market once the number of firms producing a good equals or exceeds two. For then, under perfect contestability, each such good must be priced at its marginal cost, which will be the same for all of its producers*' (Page 468).

At first glance it would appear that the sheer scale of sunk cost associated with entering the generation market and the lack of any comparable recoverable value on exit, must mean that the market does not allow costless exit and is therefore not contestable in any meaningful way. In turn this would suggest that generators should be able to obtain sufficient market revenue to earn an appropriate return on their investment. However, further consideration of generation market characteristics leads to a different conclusion, with consequences for both conventional and renewable generators.

Whilst the issue of significant sunk costs for both entering and exiting the market would generally be considered fatally to undermine any assertion that the generation market can be considered contestable, market entry also involves a lengthy and costly period to complete the processes of permitting, design, procurement and construction. In a contestable market, incumbent(s) would be aware of the new entry underway and act to lower the financial return available to the new participant however, for reasons described below, they will not do this. Together these issues would also deny contestability, as they preclude any possibility of temporary market participation and profitability, based on arbitraging an incumbent's unsustainable pricing model. However, the intrinsic requirement for oversupply of generation capacity on any system, as a result of the diurnal and seasonal variation in demand and reserve to cover planned or unplanned outages, means that there will always be non-running capacity available to run, whether required to meet market demand or not. The sunk cost objection to generation being a contestable market therefore falls away.

Turning to the applied requirement for contestability, that all generators are able to serve the same market demands and use the same productive techniques, it is clear that all generator units using the same technology are essentially substitutable for each other; differentiated only by age-related issues of efficiency, reliability and fuel hedging strategy. In making their original investment decision, each unit's investors will have concluded that they have advantages in these areas that will allow them to make a profit, even if the market price falls in response to their entry. Their investment analysis will also have assumed that if their perceived cost advantages are real, they will be able to undercut incumbents' prices and sell as much of their output as the quantity demanded by the market, at their own price; that is, the plant will operate at full load for as long as its costs retain some advantage and demand is not a constraint. On this test, the generation market would likely be contestable.

The final test for contestability is the price that a generator can obtain for its output. One possibility is that the generator commits to sell power at a defined price to a retail supplier for a period of time. This is a useful approach where project financing is used to fund a new generation plant and renders a new facility largely indifferent to the spot market price for energy. It will procure energy from the market if the price falls below its own production cost and generate whenever price is higher. The generator's objective is to negotiate an offtake price that fully remunerates its fixed costs of finance, operation and return on investment and also covers its variable operation and fuel costs. In a mature competitive market, both power purchasers and producers recognise their own duration-specific risks and will aim for these to be reflected in their contracts. Power purchasers will have concerns about customer loyalty and may not wish to enter into contracts lasting the full duration of a generator's financing commitment. The generator is therefore under pressure to offer shorter-term offtake contracts that better meet its customers' risk profiles and these shorter-term contracts inevitably face pressure to align with current market prices at the time of re-negotiation.

One unusual factor that must be considered in relation to the pricing of generation offers into the market is one that is probably unique to the electricity market. This is that electricity market pricing operates on the basis that increasing demand is met by dispatching generators in order of increasing short-run marginal cost. When the market operates on the basis of a clearing price, the last plant on will generally only recover its fuel cost, but other, cheaper plant delivering at the same time will access the same price. Depending on the relative fuel costs of different generation technologies, baseload generation plant may in practice achieve revenue equivalent to its long-run marginal cost, but there is no guarantee of inherent revenue adequacy in a market; particularly for long-lived assets that may well be superseded by newer technologies within their lifetimes.

For generators whose financing costs have been amortised, their fixed costs of operation will be materially lower than those of newer plant, with the consequence that an acceptable financial return can be had at a price that is materially lower than that of a newer plant, even if the latter is more efficient in terms of its variable cost of production. The incentive for fully-depreciated plant is therefore initially to maximise its inframarginal revenue by maximising its running hours and offering power into the market at a price that is just below the long-run marginal cost of the newer plant. In turn, the newer plant will be incentivised to respond by bidding its lower production cost to maximise its running hours and therefore its inframarginal revenue, even though this may turn out to be some way below its target to recover its long-run marginal cost. This can be justified on the basis that the concept of long-run cost is somewhat nebulous, depending on ill-defined factors around expected plant life and finance rate and duration, that may change over time. However, the important point to note is that over-supply of generation (an intrinsic aspect of the market) will incentivise generators to bid their output into the market at a price close to their short-run marginal cost, in the hope of earning additional, inframarginal rent.

Any relief that hedging contracts might offer from this competitive pressure is likely to be relatively short lived, at least in comparison with the asset life, as power purchasers note the impact of competitive generator offers in the spot market and calibrate their expectations of contract price duration accordingly. Generators therefore face commercial pressures to maximise revenue by pricing their output at a level close to their short-run marginal cost and seek a contribution to their fixed costs from inframarginal revenue. In summary, it is reasonable to conclude that a competitive electricity generation market, even where production capacity is optimised with respect to demand, is much more contestable than might initially be thought. When combined with a competitive market structure, such a system is unlikely to be sustainably revenue-adequate for all plant capacity required to ensure supply reliability, unless some form of capacity support mechanism is provided. This has significant implications for markets seeking to maximise renewable participation.

With the exception of technologies having input energy storage capability, new renewable capacity is not dispatchable in the same way as conventional plant. When output is available, its production cost is essentially zero, exerting a downward pressure on market prices. As the proportion of renewable generation in a competitive market increases, running hours for conventional generators will decrease, although reliability requirements may remain little changed. With the loss of ability to earn inframarginal revenue, conventional generators will increasingly depend on capacity support payments, but there will also be pressure to close capacity.

In conclusion, contestability of the generation market indicates that even conventional generators will depend on some form of capacity support mechanism in a competitive market, although such payments may be made opaquely, e.g. through bundling with the overall market price. However, as the level of renewable generation in a market increases, the ability of conventional generators to access such bundled support will be reduced, which will have the effect of forcing the support to become explicit. A perverse outcome of successful deployment of renewables in a market is therefore that a support mechanism will likely be required for conventional generators to maintain system reliability, unless the renewable capacity mix includes sufficient a sufficient component of dispatchable generation.

In a largely renewable market with capacity payments being made to conventional generators, the question arises as to whether these will act to inhibit or promote further renewable rollout. The answer depends on the nature of these payments. To support ongoing renewable development, capacity payments should obligate technical characteristics that complement the attributes of renewable generation, such as support for system reliability and output flexibility. They should also be of fixed duration.

6.3 Reliability

Consumers expect, with greater or lesser degrees of confidence, that their lights will come on whenever they turn the switch, which means that the power system must be in balance at every moment in time and with sufficient reserve to meet the increased demand. From the System Operator (SO) perspective, this means that there must be a high level of confidence that any plant scheduled to operate will deliver the expected amount of energy. Dispatchability means that system operation can be planned weeks or months in advance, with the final running order being refined closer to real time, as new information on availability or performance becomes available. Even in competitive generation markets the SO will require generators to provide availability information and will co-ordinate maintenance outages.

Another basic issue from the SOs point of view is that the overall power system must be stable and resilient to any network outage, loss of generator output or change in consumer demand. Operational failures like these are expressed as sudden falls in system frequency that require other plants on the system to adjust their output to compensate and thereby to bring the system back into balance.

The physical mass of traditional, heavy rotating generation plant means that the mechanical inertia of the machine's rotating elements will store a considerable amount of kinetic energy during operation. The electro-magnetic coupling between alternator rotor and stator, allows this mechanical inertia plus additional energy stored in its boiler or reservoir, to maintain the machine's electrical output in the initial stage following a fault and supports the wider system until the output of remaining plant can be increased to rebalance the system. By its nature the amount of inertia available to a power system will vary over the day and year as the operational plant mix changes but maintaining it at an appropriate level is essential for management of fluctuations in system frequency.

As discussed earlier, one of the characteristics of many renewable generation technologies is that they are non-synchronous, with the result that the SO may curtail the amount of such plant allowed on the system at any one time. However, this is unlikely to be a concern until the instantaneous penetration of non-synchronous generation on the system reaches a level of 50% or so, as Eirgrid has shown. Few other countries have reached this level of such renewable capacity, but the Irish experience is that measures to increase non-synchronous generation beyond this level will take a number of years. While other system operators will benefit from Eirgrid's experience, markets in which renewable deployment is regarded as having been successful should have plans in place to address the issue of inertia, if their success is to be maintained.

6.4 Regulation

As previously described, generation assets are expensive, long-lived and immovable; presenting a challenge to any investor seeking a quick exit from such an investment. This means that renewable investment is only likely to take place in an environment where there are clear market rules that are enforced by a powerful and independent body with relevant expertise. These rules must guarantee equality of treatment for all participants and be underpinned by a transparent legal framework.

When considering the sustainability of any country's renewable investment strategy, or indeed in seeking to understand the failure of an apparently sound renewable policy, an early consideration must be whether or not such a robust regulatory framework is in place. As discussed later, in relation to the US experience, it is not necessary for actual anti-competitive behaviour to exist in a market in order for investment by potential market entrants to be discouraged. The perceived risk on its own is sufficient to act as a deterrent. For a regulatory framework to be successful in promoting renewables, or indeed any form of competitive generation, it must separate ownership and operation of the grid from ownership of generation assets. This approach has been adopted by the European Union, as well as the US and Russian regulators, whose progress in delivering renewable deployments in their respective markets is discussed in the next section.

7 Relevance to Renewable Investment

If the above economic and regulatory issues actually influence investor behaviour in the real world, then we should expect to see any successful programme for expansion of renewable generation capacity being preceded by legal reforms that deliver an orderly dismantling of prior monopoly arrangements and create a supportive commercial environment for independent producers entering the market.

Financial underpinning of renewables can take many forms, but the most important issue is that rapid expansion of renewable generation in any market can only be expected if there is widespread investor confidence in the new, more open economic environment. If there is limited or no competition in the retail market, then revenue adequacy for all generation can be assured by retail price regulation that delivers sufficient income to provide the target level of support. But, where competition is a significant market feature, then levies will be necessary to fund mechanisms such as renewable production credits or price guarantees that can complement any capacity payment arrangements that supplement inframarginal rent earned through market operation. For renewable developers, revenue support arrangements are almost certainly needed to mitigate lenders' risks and thereby allow access to the lowest-cost development capital. Support ensures that lenders face only normal project quality risks (e.g. engineering quality, operational skill and resource reliability). Its absence adds in market price risk. In practice therefore, significant renewable development is unlikely in the absence of such support.

In markets where good progress has been made in the deployment of renewables, the sustainability of progress should be evidenced by the deployment of renewables-supporting technologies, such as storage and system operator programmes facilitating further increases in renewable production. At some point, when renewable output is having a material impact on the running hours of conventional plant, some form of capacity revenue support arrangements can be expected for the non-renewable generation that is still required to provide ongoing system reliability. However, this support is separate from arrangements aimed at supporting renewable investment and should be structured to provide capacity of a type that is compatible with the characteristics of renewable generation technologies present on the system.

Having established the importance of competitive issues in generation economics and the role of government and regulation in providing frameworks that support investor confidence, it is reasonable to expect that actual delivery of renewable policy is only likely once effective market access reforms and appropriate revenue support arrangements have been implemented. While each country's decisions on how best to deliver its renewable generation policy ambitions will depend on its own history and cultural environment, any dependency on successfully harnessing non-governmental investment for delivery must address these access reform and financial framework issues before real progress can be made. If policy choices or global economic circumstances constrain these reforms, then delivery outcomes will reflect the compromises that have been made.

8 Testing the Hypothesis—Two Case Studies

A comparison of two contrasting markets will be helpful in examining how effective their respective approaches to access reform and financial framework development have been in practice. For this exercise, the United States (US) and the Russian Federation have been chosen. Both markets have set targets for renewable generation capacity and both markets started from a position of monopoly market structures; municipal or investor-owned in the US and state owned in the case of Russia. Data for the US is available in great detail from the US Energy Information Administration (EIA), that compiles what is generally regarded as the most comprehensive dataset on the US market, while information on the Russian market has been obtained from the market supervisory organisation (NP Market Council) and the market operator (ATS Energo). A final point about the Russian market is that there are significant areas where population density or lack of network interconnection means that competitive market structures have not been implemented. However, there are two 'price zone' areas, where market prices are calculated and renewable support mechanisms are in place to support investment.

To begin with, some appreciation of the physical differences between these two countries and their electricity industries is required to provide a context within which progress in delivery of their renewable goals can be assessed. In terms of physical size, the Russian Federation is almost double the area of the US: at almost 17.1 million km^{2,} compared with 9.8 million km^2 for the US, it is physically the largest country in the world (World Bank, 2017a: 1, b: 2). In contrast, with a population of 146.9 million (Rosstat, 2018), it is much less populous than the US with 328.2 million (United States Census Bureau, 2018). The US and Russia are also significantly different in terms of geography, climate and stage of economic development, although both have similar levels of technological expertise.

8.1 US Experience

Information from the EIA (Fig. 16.1) shows just how electrically interconnected the US is, with over 580 thousand km of transmission lines transporting 4,015 TWh of bulk power in 2017 (EIA, 2018).

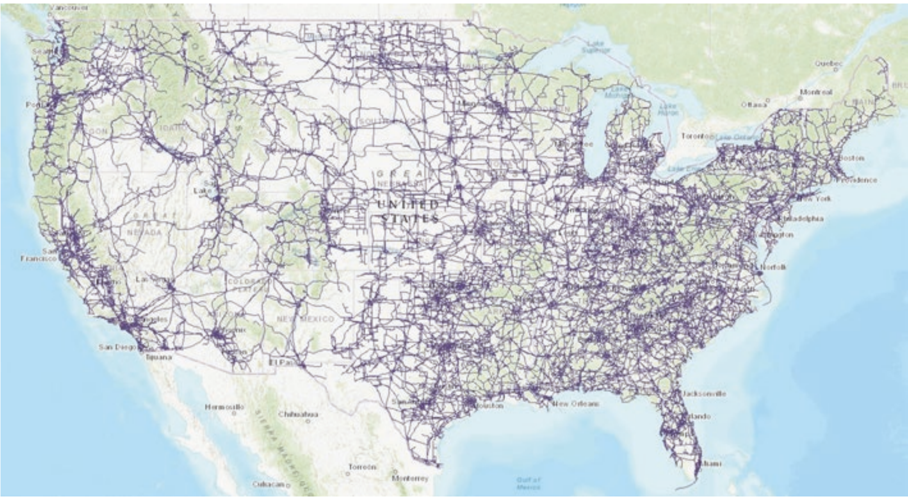

Fig. 16.1 US Electricity system transmission lines. (Source: Energy Information Administration, 2018)

Originally, vertically-integrated, municipal, co-operative or investor-owned monopolies made access by independent power producers more difficult because of real or perceived lack of a level playing field for connections and access to market.

First moves towards encouraging greater equality of treatment for non-incumbent generators were made by the Federal Energy Regulatory Commission (FERC) in Order No. 888 (Federal Energy Regulatory Commission, 1996). This became effective on 9 July 1996 and required,

> *"all public utilities that own, control or operate facilities used for transmitting electric energy in interstate commerce to have on file open access non-discriminatory transmission tariffs that contain minimum terms and conditions of non-discriminatory service."*

Order No. 888 was interrelated with Order No. 889 in putting in place rules that were designed "*to remove impediments to competition in the wholesale bulk power marketplace and to bring more efficient, lower cost power to the Nation's electricity consumers*", by ensuring non-discriminatory pricing for access to transmission systems. In other words, market entrants would enjoy the same access to markets and transmission information as was available to the incumbent utility. It also allowed cost recovery for certain utility stranded costs associated with the provision of open access.

At the time these rules were being devised, FERC had recognised the difficulty of ensuring true equality of access to transmission networks when these were owned by entities that also owned generation. Order No. 888 therefore included provisions to ensure functional unbundling of generation from networks, thereby encouraging the formation of Independent System Operators (ISOs) and Regional Transmission Operators (RTOs), as network owning companies restructured to ensure compliance with the new regulatory obligations.

Some three years after Order No. 888 became effective, in December 1999, FERC issued Order No. 2000 (Federal Energy regulatory Commission, 2000), that became effective on 6 March 2000. The aim of this Order, entitled "Regional Transmission Organizations", was "*to advance the formation of Regional Transmission Organizations* (*RTOs*)." Regulations in this Order required each public utility that owned, operated, or controlled facilities for the transmission of electric energy in interstate commerce to make certain filings with respect to forming and participating in an RTO. This Order was a substantial document, of over 700 pages, including discussion of issues raised in the consultation period following the FERC's Notice of Proposed Rulemaking (NOPR). It addressed issues such as specification of minimum characteristics and functions of an RTO, the requirement for RTOs organisational arrangements to be adaptable to meet future market needs and transmission ratemaking (tariffing) policies to be followed.

In summary therefore, between 1996 and 2000 the US electricity sector was transformed by regulatory action. A relatively small number of ISOs and RTOs began to emerge from a much larger collection of vertically-integrated and competitively obstructive utility monopolies, to provide non-discriminatory access to the transmission system for all generators and elimination of charging arrangements that acted as barriers to competition.

The other important incentive for renewable generation development in the US has been the renewable generation Production Tax Credit (PTC) (United States Energy Department, 1992). This is "*an inflation-adjusted per-kilowatt-hour (kWh) tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year*", that lasts for 10 years from the date the plant is put into service. Originally set at £0.015/kWh when introduced in 1992, at the time of writing in 2018, the tax credit is now $0.023/kWh. However, for wind facilities commencing construction in 2017, 2018 and 2019, the PTC is being stepped down by 20%, 40% and 60%.

In combination, equal access to the grid, the PTC and resources mobilised by the many developers keen to enter the market following implementation of FERC Order 2000, lead to explosive growth in the installed capacity of renewable generation, as shown in Fig. 16.2.

While the EIA is the most authoritative source of energy data for the US, there have historically been data missing from its published information as new technologies have come into use, for example, as householders have become generators through the installation of rooftop solar PV. In this regard the IEA has only recently started to estimate the amount of embedded small solar capacity, although it now estimates that this may have added a further 12 GW, and growing, level of capacity to figures published in recent years.

Another factor pointing to the maturity of the US renewable market is the emergence of non-hydraulic energy storage capacity being deployed in the market. EIA figures for 2017 include 0.7 GW of battery, 0.11 GW of gas with compressed air and 0.04 GW of flywheel storage in service, with a further 0.7 GW planned by 2023. Development of these storage facilities, including use of batteries for system frequency control, suggests that the system operators' market for system services is preparing for significant further expansion of renewable generation capacity, even though the capacity of further projects noted in the national database tails off beyond 2021.

Information available for the US therefore appears to support the hypothesis that regulatory action in the year 2000 to level the commercial playing

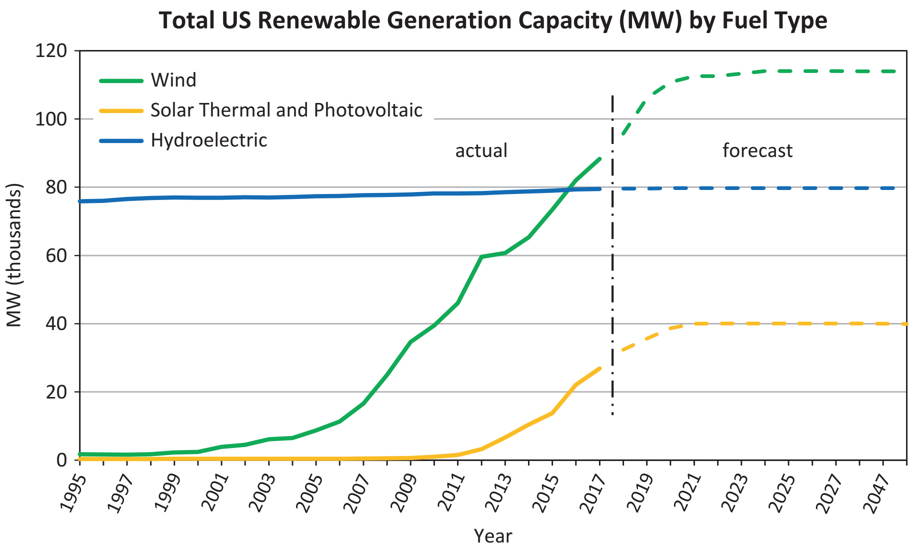

Fig. 16.2 Growth in US renewable generation since 1995. (Source: Raw data sourced from EIA, 2018)

field, together with a federal government guaranteed scheme to provide a form of revenue support, has lead to the emergence of a large number of private developers entering the market and delivering substantial new renewable generation capacity. However it is also clear that the maturity of technology is also a factor. The EIA data shows that wind was able to take advantage of regulatory reform almost immediately, whereas solar PV took nearly a decade to emerge as a material contributor to renewable capacity.

Further research might identify whether this coincidence of market reform and rapid capacity expansion was a result of maturing wind technology, or a mismatch between the level of PTC and technology cost. However, the data does suggest that PTC support was not enough, on its own, to initiate the deployment of renewable generation to any significant extent and is consistent with the hypothesis that both regulatory reform and revenue support measures are required for effective development of renewable generation. Russian experience, where market reform came before introduction of effective revenue measures, suggests the US experience was not particularly technology-driven.

8.2 Russian Federation

The Federal Grid Company of Russia owns more than 142.4 thousand km of the Unified National Electric Grid transmission system, with an operational area of 15.1 million km,[2] the system transmitted 1,040 TWh of bulk power in 2017 (Public Joint Stock Company Federal Grid Company of the unified energy system, 2017: 7).

Given the physical scale of Russia's territory, the relatively small scale of its electricity transmission system compared with that of the US might be surprising. However, the former's grid reflects the country's climate, development history and pattern of settlement. In the case of Russia, the relative lack of interconnection poses a challenge for economic exploitation of the country's renewable energy resources. The fact that some areas are not physically connected to the Unified Electricity System and have been excluded from market entry arrangements for independent producers adds to the complexity of any attempt to offer a concise description of how the sector has evolved from the Soviet monopoly structure to the present day. However, available data are sufficient to gain some understanding of how restructuring of the electricity industry and establishment of a price support regime have affected development of renewable generation projects.

Association NP Market Council is the market supervisory organisation for the Russian electricity market to which all wholesale market participants must legally belong. It also controls ATS Energo; the market operator for price zones 1 and 2, in which wholesale prices are unregulated and set by market rules. Figure 16.3 shows the division of the country into zones where organisational unbundling of monopoly and competitive activities is mandatory and where wholesale market pricing applies, along with the non-price and isolated zones in which special, regulated prices apply (Association NP Market Council, 2019).

A more thorough exploration of the interaction between geographic, political and industrial power structures and the central government's reforming objectives in relation to the Russian electricity sector was undertaken by Wengle (2011) and is a useful starting point for understanding the context in which the Russian electricity market has evolved.

Changes to the Russian electricity sector began seriously in 2001 and are outlined in the grid company's 2002 annual report (Public Joint Stock Company Federal Grid Company of the unified energy system, 2002: 1). In summary, the decision was made to reform the power industry and restructure it along the lines of naturally monopolistic and competitive types of activity, on the basis of Government order (No. 526). Soon after, implementation of stage 1 of the plan was approved by Decree 1040-p, that initiated structural reforms as a preliminary step towards implementing a competitive electric power market. A significant step was to establish the "Federal Grid Company of the Unified Energy System" as the main grid owning company for the Russian Federation. Among other objectives, this company is required

Fig. 16.3 Price and non-price zones for electricity in the Russian Federation. (Source: Association NP Market Council, 2019)

"*to guarantee equal access of sellers and buyers to the wholesale market of the electric power*". Federal Laws Nos. 35-FZ and 36-FZ (2003) set out the basic framework of the industry transition to a market-based system, with subsequent legislation, Government Resolution No. 1172 (2010), establishing rules for the wholesale market.

From the perspective of renewable generation, the most significant legislative event has been Government Resolution No. 449 'On the mechanism of promoting the use of renewable energies at the Wholesale Electricity and Capacity Market' (28 May 2013). From this brief overview, it is clear that there has been a steady evolution of the legal framework underpinning changes to the electricity industry structure during the first decade or so of this century, to deliver equality of system and market access rights. These changes have followed a consistent policy path that is transparent and supportive of investors; a situation confirmed by the entry of non-Russian companies into the energy market.

In looking at development of the renewable generation market in Russia, key dates would therefore be: 2003 when arrangements for transition to a market model were defined; 2004 when non-discriminatory access to the grid was guaranteed for all participants; 2010 when wholesale market rules were defined; and 2013 when Resolution No. 449 set out the mechanism for promoting renewable energy in the wholesale market.

An unusual feature of the Russian renewable support mechanism is that it is a contract for the provision of capacity rather than exported energy, although the achievement of reasonably attainable capacity factors for each technology is essential to ensure projects receive their full payments and avoid financial penalties. Projects must also be controllable (downwards) in response to System Operator instructions, if financial penalties are to be avoided. In terms of effectiveness, it matters little whether renewable support is based on capacity, or output-based as in US, the effect is similar in terms of mitigating lender risk. However the cost of capacity-based schemes can obviously be more easily predicted.

There are three other factors designed to integrate Russian capacity support arrangements into the country's wider policy for economic development:

- cost of the support programme is controlled by annual limits on the total capacity of renewable contracts awarded in each annual round;
- targets are set for local content that must be included in each project, for each technology type; and
- A maximum price per kW is set for each technology type, although contracts are awarded on the basis of the actual prices bid by applicants.

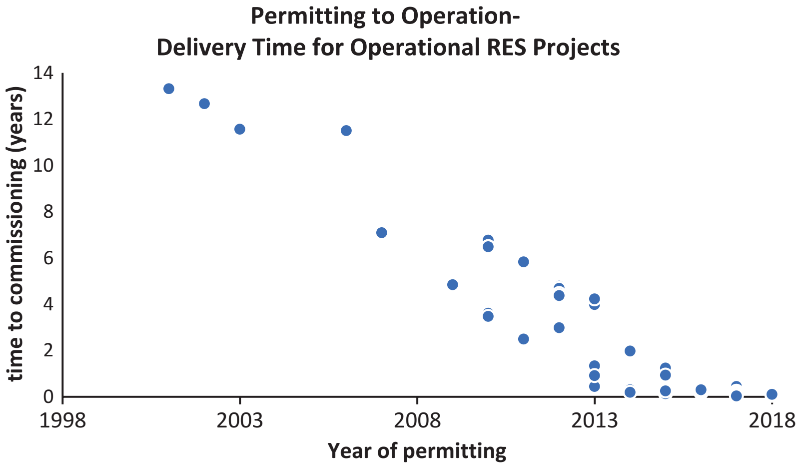

Fig. 16.4 Delay between project permitting and operation. (Source: Data from ATS Energo)

Although some commentators suggested that the above parameters, defined by Resolution No. 449, would be unduly onerous and risky for investors, this has not turned out to be the case. Indeed the Market Operator's (MO) report for that first OPV[1] selection process resulted in the award of contracts for 1,081 MW of renewable capacity, across 76 projects, for delivery by 2015. Subsequent project selection rounds have been equally successful, with projects totalling over 5.3 GW of renewable capacity being awarded contracts since 2013, although these have often been awarded to consortia featuring established foreign industry players, rather than to numerous small-scale developers. For example, one consortium involving Fortum Energy of Finland was awarded 1 GW of wind capacity contracts in 2017, while ENEL of Italy secured 291 MW.

Effectiveness of the Russian electricity market reforms in terms of delivering renewable generation capacity can also be gauged from MO data on the time taken to deliver projects following completion of the permitting process. Figure 16.4 shows data for 65 operational renewable projects that have been permitted since 2001. This shows the time elapsed between obtaining permits and the projects becoming operational in the market (i.e. shown as operational in the MO register). The correlation between length of delivery

[1] OPV is the English language acronym used by ATS Energo (Administrator of the Trading System of the Wholesale Electricity Market) for the 'Selection of RES projects' (Отбор проектов ВИЭ); This is the process for "competitive selection of investment projects for the construction of generating facilities operating on the basis of using renewable energy sources."

process and progress with industry structural and market reforms is too striking to be merely coincidental and, although a significant proportion of these pre-dated the OPV process, projects developed under this scheme are now (2018) being commissioned. Available evidence therefore supports the hypothesis that renewable energy projects are held back by uncertainties over the stability of market access and commercial arrangements. This is consistent with the intuitive perception that, rules ensuring long-term equality of market access and contractual financial support, increase both the number of projects coming forward and speed up delivery through reducing complexity of the process.

Overall there appears to have been lively private interest in competing for renewable capacity contracts, with successful developers being sufficiently confident to offer prices within the price limit. However, a comparison between delivery dates promised by successful bidders in the OPV auctions and renewable capacity actually registered as operational in the market (see Fig. 16.5), suggests that the 5.3 GW of operational renewable capacity that successful bidders promised by 2023, may be somewhat optimistic.

A detailed analysis of this discrepancy is beyond the scope of this chapter, but reasons could range from specific Russian issues, such as challenges in meeting local content requirement, the more generic issue of "paid-as-bid" auctions where projects turn out to be undeliverable for the offered price, or any of the myriad holdups common to developers in any jurisdiction. In spite of delays, it is clear that renewable delivery is gathering momentum and that wind energy is becoming the dominant technology, with capacity contracts awarded in the 2018 OPV process being almost six times the total for solar photovoltaic. By way of comparison, solar PV was awarded just under four times the capacity of wind in the initial competition, in 2013.

A final and important point to note is that the OPV process does not tell the whole story about renewables in the Russian Federation. Outside of the price zones, RusHydro (2018a), the 60% government-owned power company, is currently building approximately 2.1 GW of large hydro projects ranging in capacity from 320 to 840 MW, to add to its existing 30 GW of renewable generation (RusHydro, 2018b).[2] The scale of these major hydro developments contrasts sharply with the 160 MW of small hydro project awarded capacity contracts over the 6 years of the OPV (Resolution 449) process that is designed to support solar PV, wind and small hydro (under 25 MW).

[2] A more comprehensive overview of current and potential renewable generation capacity in the Russian Federation can be found in International Renewable Energy Agency (IRENA, 2018).

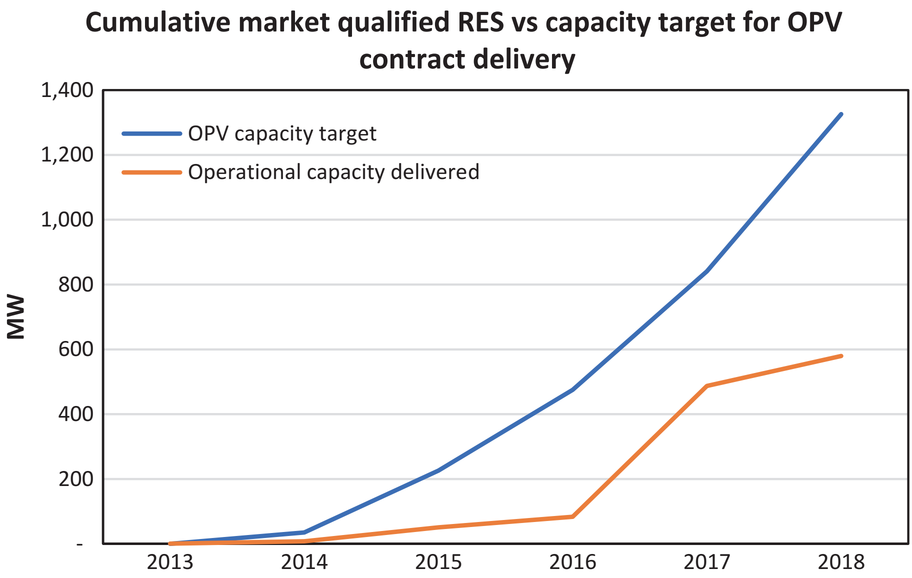

Fig. 16.5 Comparison of MW delivery target for OPV contracts with operational capacity, by year. (Source: Data from ATS Energo, 2019; Association NP Market Council, 2019)

9 Conclusion

The deployment of renewable generation has faced a different set of challenges from those faced by conventional, fossil generation as economies electrified in the early twentieth century. With the exception of hydro-electric generation, renewables have comprised a collection of emerging and developing technologies trying to enter established and technically more or less optimal markets already occupied by well-understood and reliable conventional technologies. In addition to capacity duplication, the large-scale addition of zero marginal cost renewables disrupted the economics of conventional plant that operated in markets designed on the assumption that marginal production cost increases with increasing demand. In this respect, new renewable generation only increased visibility of the already-existing issue of revenue adequacy in competitive electricity markets.

The central argument of this chapter is that there are certain basic characteristics of competitive electricity market economics that must be addressed before investors will risk long-term investment in new generation assets, irrespective of whether their investment is in conventional or renewable capacity. The challenge for governments and regulators has been to create legal and regulatory frameworks that maintain investment in clean generation capacity, at an acceptable public cost, without precipitating uncontrolled market exit by the conventional generation plant that has ensured stable and reliable operation of the overall electricity system. The challenge for power system operators has been one of learning to manage the technical transition from large, dispatchable, transmission-connected fossil generation plants to an environment of more distributed generation facilities, with less predictable output and significantly different capability to provide essential system services.

In summary, this chapter has argued that significant private investment in renewable generation capacity is unlikely in any competitive market, unless the two fundamental issues, of equal market access and revenue support are addressed. The assessment of US and Russian electricity markets contained in this chapter suggests that this argument is well-supported by the evidence. Investment must be underpinned by a legal and regulatory framework that ensures equal system and market access for new assets over their economic life and the system overcapacity issue addressed through some form of price support or revenue guarantee arrangement. In the medium term, sustainability of renewable deployment programmes is dependent on the introduction of new system services and technical measures that address specific reliability characteristics of individual markets.

Russia and the US could not be more different in terms of their power industry origins, path of market development and current stage of renewable deployment. In terms of revenue support and market access, tax breaks came before structural reform in the US, whereas structural reform came first in Russia. But it is significant that neither jurisdiction was able to make material progress with renewable deployment until both regulatory and revenue support measures were implemented within the competitive market arrangements. It might be argued that wind and solar PV generation technologies were too immature for large-scale deployment when production tax credits were first introduced in the US but, as Fig. 16.3 shows, delivery of Russian renewable projects permitted in the first years of the millennium was subject to considerable delays. The balance of probability is therefore that the stage of renewable technological maturity is less important to delivery than the regulatory and financial environment into which it is to be deployed.

At the time of writing, the US has had almost 20-years of experience delivering renewables, so there is sufficient data to detect a trend of success. On the other hand, it has only been 5 years since Russia's arrangements were implemented in mid-2013 and it is too early to tell if promised capacity will be delivered; Figure 16.5 certainly suggests that delivery dates promised by a number of successful applicants for OPV renewable capacity contracts may have been somewhat optimistic. On the other hand, the scale of renewable deployment in the US has now reached the stage where there is a net retirement of conventional plant capacity and system operators are implementing technical solutions to enhance grid stability in a high-renewable environment.

In conclusion this chapter has demonstrated that any assessment of renewable deployment in a jurisdiction should start with an assessment of whether the regulatory environment ensures long-term equality of market access for renewables and whether mechanisms are available to support revenue adequacy. In this regard, the outlook for renewable deployment in both Russia and the US is positive, as both these requirements are in place. However, future progress assessments should consider the impact of falling levels of production tax credits in the US and the effectiveness of system operator measures that aim to reduce curtailment of renewable output. For Russia, the focus should be on actual delivery of projects promised through the OPV competitive process, in addition to market operator data on renewable output.

References

Association NP Market Council. 2019. About the Electricity Industry—General Information. http://www.en.np-sr.ru/en/srnen/abouttheelectricityindustry/generalinformation/index.htm.

ATS Energo. 2019. News Feed. https://www.atsenergo.ru/.

Baumol, W.J., Panzar, J.C. and Willig, R.D. 1982. *Contestable Markets and the Theory of Industry Structure*. Harcourt Brace Jovanovich Inc.

Boiteux, M. 1949. La tarification des demandes en pointe: Application de la théorie de la vente au coût marginal. Revue Générale de l'Électricité.

Boiteux, M. 1957. The Role of Amortization in Investment Planning. *International Economic Papers* 10: 161–162 (translated from Revue de Recherche Opérationelle).

Commission for Energy Regulation. 2004. Wind Generator Connection Policy, Direction by the Commission for Energy Regulation. CER/04/245.

Energy Information Administration (EIA). 2018. US Energy Mapping System—Electric Transmission System Layer. https://www.eia.gov/state/maps.php.

European Community. 1996. Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 Concerning Common Rules for the Internal Market in Electricity, Article 8(3).

European Community. 2001. Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market. Annex.

Federal Energy Regulatory Commission. 1996. Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, Order No. 888. Federal Register Vol. 61, no. 92, May 10, 1996.

Federal Energy Regulatory Commission. 2000. Regional Transmission Organizations, Order No. 2000 Federal Register Vol. 65, no. 4, January 6, 2000, p. 810.

International Renewable Energy Agency (IRENA). 2018. Renewable Energy Prospects for the Russian Federation (REmap Working Paper): April 2018. https://www.irena.org/publications/2017/Apr/Renewable-Energy-Prospects-for-the-Russian-Federation-REmap-working-paper.

Ó Gallachóir, G. 2004. The Grid Connection Moratorium in Ireland. Proceedings of the European Wind Energy Conference 2004, Figure 1, November 22–25, London.

Public Joint Stock Company Federal Grid Company of the Unified Energy System. 2002. Reforming of Electric Power Industry in the Russian Federation, Annual Report for 2002.

Public Joint Stock Company Federal Grid Company of the Unified Energy System. 2017. Market Review: Annual Financial Report for the Year 2017.

Renewables Now. 2012. China's 22.5-GW Three Gorges Dam Reaches Full Capacity, July 5, 2012. https://renewablesnow.com/news/chinas-22-5-gw-three-gorges-dam-reaches-full-capacity-287247/.

Rosstat. 2018. Population. Russian Statistical Yearbook, http://www.gks.ru/bgd/regl/b18_13/Main.htm.

RusHydro. 2018a. Hydrogeneration. http://www.rushydro.ru/activity/1B3ADB8F7A/.

RusHydro. 2018b. Investor Presentation: Renaissance Capital 22nd Annual Russia Investor Conference, April 10–11, 2018. http://www.eng.rushydro.ru/upload/iblock/6ce/RusHydro_Apr_2018_MOEX.pdf.

Turvey, R. 1968. *Optimal Pricing and Investment in Electricity Supply; An Essay in Applied Welfare Economics*. George Allen and Unwin Ltd.

United Kingdom Government. 1983. Energy Act 1983.

United States Census Bureau. 2018. US and World Population Clock. https://www.census.gov/popclock/.

United States Energy Department. 1992. Renewable Electricity Production Tax Credit (PTC). https://www.energy.gov/savings/renewable-electricity-production-tax-credit-ptc.

Wengle, S.A. 2011. Post-Soviet Developmentalism and the Political Economy of Russia's Electricity Sector Liberalization. http://cis.uchicago.edu/oldsite/outreach/summerinstitute/2014/documents/wengle/sti2014_wengle2012_postsovietdevelopmentalism.pdf.

World Bank. 2017a. World Development Indicators. https://databank.worldbank.org/data/reports.aspx?source=2&country=RUS.

World Bank. 2017b. World Development Indicators. https://databank.worldbank.org/data/reports.aspx?source=2&country=USA.

17

Prolonging Fossil Fuels or Hastening the Low-Carbon Transition? The Diffusion of Biofuel Development: Motivations and Strategies

Jale Tosun and Trevelyan S. Wing

1 Introduction

In the wake of the 2015 Paris Agreement, nations around the world pledged to intensify their efforts in implementing transition pathways to a low-carbon economy (Tobin et al., 2018). Indeed, the accord's ambitious target of limiting global mean temperature rise to 1.5 degrees Celsius can only be met if substantial carbon emission reductions are achieved. This will necessitate a dramatic decrease in fossil fuel use worldwide. At the same time, however, domestic worries in many countries regarding sector-related jobs and state revenues—among other concerns—have led a number of governments to plan for a managed decline of fossil fuels, rather than the rapid rollback advocated by many environmental groups.

In this context, the promotion of biofuels has become a popular strategy—one adopted by numerous governments (Demirbas and Balat, 2006; Tosun, 2017). Biofuels are regarded as reducing dependence on oil imports, mitigating greenhouse gas emissions, and stimulating domestic economic development (Khanna and Chen, 2013: 1325). They also constitute the main type of renewable energy used for fuel in the land transport sector, an area hitherto dominated by petroleum. Indeed, a so-called 'biofuels frenzy' has, since the early 2000s, sought to make inroads in the transport fuel market, with countries around the world promoting biofuel development (Ackrill and Kay, 2014; Bomb et al., 2007; Tolmac et al., 2014). The European Union (EU), as the third largest producer of

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biofuels after the United States (US) and Brazil, has seen significant policy proliferation in this area over the past decade and a half (Tosun and Schulze, 2015). Many EU member states have approved policies for promoting sector growth on the one hand, while steadily removing existing obstacles on the other—often through extensive public funding (see Balat, 2007; Di Lucia and Kronsell, 2010; Di Lucia and Nilsson, 2007; Eikeland, 2006; Lovio and Kivimaa, 2012; Schleifer, 2013; Skogstad, 2017). The intention of the policies adopted is not to completely substitute fossil fuels with biofuels, but rather to increase their share in fuel consumption and, more generally, to contribute to a diversification of energy resources.

Essentially liquid or gaseous fuels extracted or fermented from plant matter and residues, biofuels can be produced from different types of organic matter (feedstocks) ranging from crops and agricultural and forestry byproducts to municipal waste. Ethanol and biodiesel constitute the two main forms of biofuel, the former produced from sugars and the latter from oils (Ackrill and Kay, 2014: 4). Biofuels are not only differentiated as either ethanol or biodiesel, but also according to their 'generation.'

'First generation' biofuels are characterized by their ability to be blended with "*petroleum-based fuels, combusted in existing internal combustion engines, and distributed through existing infrastructure, or by* [their] *use in existing alternative vehicle technology like FFVs ('Flexible Fuel Vehicles') or natural gas vehicles*" (Naik et al., 2010: 579). It is this type of biofuels that has been criticized by environmental groups as being unsustainable (see Tosun, 2018a, b), an issue that we will return to later in this chapter.

'Second generation' biofuels, meanwhile, are produced from plant biomass, which refers mainly to lignocellulosic material (Naik et al., 2010: 579). The development and use of lignocellulose biomass in future production of fuels and materials is part of a global innovation agenda termed the 'bioeconomy' (McCormick et al., 2012; McCormick and Kautto, 2013). The bioeconomy is a vision for "*the knowledge-based production and utilization of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors*" (International Advisory Council of the Global Bioeconomy Summit, 2015: 4). We contend that the advancement of the bioeconomy has helped biofuels (re-)enter the political agenda in both developing and developed countries.

This chapter investigates the striking similarity in biofuel development strategies within a group of fifteen remarkably different states in North and South America, Europe, Asia, and sub-Saharan Africa. How extensive are the similarities across countries when we differentiate between 'generations' of biofuels, and how might we explain these in terms of the biofuels-related policies observed? To address both questions, we draw on policy reports and relevant scientific articles on the respective governments' rationales for promoting biofuels.

The remainder of this chapter is structured as follows: first, we briefly outline the biofuels controversy, which needs to be taken into account when examining the diffusion of biofuel promotion policies. Next, the empirical puzzle is presented in detail alongside background information on the countries analysed, followed by a discussion of the relevant biofuel policies in light of our research questions. Lastly, we summarise and elaborate on our main findings in the final two sections. Overall, this chapter provides insights regarding the relatively similar strategies adopted by a diverse set of countries in an attempt to align the goals of economic development, energy supply security, and environmental/climate protection with one another.

2 The Controversy Surrounding Biofuel Promotion

Government attempts to support the development of biofuels have been met with skepticism from a number of quarters (see for example Di Lucia, 2013: 81–82). Critics point to the fact that mandatory blending requirements for biofuels have, for example, shifted costs for biofuels onto the private sector—producers and consumers alike. The latter often bear the brunt of additional costs, whether through higher transport fuel prices resulting from the inelasticity of demand for biofuels, or what has been termed the industry's "*oligopolistic market structure*" (Rauch and Thöne, 2012: 12). Tax exemptions for biofuels, meanwhile—along with subsidies for farmers growing biofuel crops—have likewise been described as both economically inefficient and an excessive burden on taxpayers (see Henke et al., 2005). Nevertheless, Rauch and Thöne (2012, 44) contend that, without such support mechanisms to lower production costs and guarantee a share of the transport fuel market, the biofuels industry "would likely be unable to sustain itself, or at least not to the extent it has."

Other prominent critiques from non-governmental organisations (NGOs) such as Friends of the Earth (FoE) have attacked the diffusion of biofuels as doing more harm than good, asserting for example that biofuel development has aggravated—not mitigated—climate change (FoE, 2013; see also Pilgrim and Harvey, 2010). Indeed, one FoE report claims that "*increasing our use of biofuels… could cause more greenhouse gas emissions than the fossil fuels they* *replace*" (FoE, 2013: 1). A particular concern is the destruction of forestland, cleared in order to make way for biofuel crops—a process encouraged by government subsidies and targets that, if continued, could release millions of tons of carbon (FoE, 2013: 2; Levidow, 2013: 215–219). Other criticisms relate to the appropriation of large tracts of land in impoverished countries for the cultivation of biofuel crops. In this context, FoE argues, biofuel development "*is harming some the world's poorest people* [by] *stripping them of their livelihoods*" and leading millions to go hungry due to rising food prices resulting from the replacement of food crops with biofuels (FoE, 2013: 2; see also Levidow, 2013).

Despite claims to the contrary by producers and many politicians, environmental groups remain skeptical with regard to the supposed sustainability of biofuels (see Wood, 2018). In their place, FoE and other NGOs have called for more government support for public transport, the development of 'smarter' and more fuel-efficient cars, safer footpaths and bicycle routes, and—crucially—a major push for 'real' renewables like solar and wind (FoE, 2013: 2). Despite these concerns, many policymakers continue to regard biofuels as a key component of the global low-carbon transition—as evidenced by the great number of countries currently pursuing them—and, as this chapter will reveal, an opportunity for enabling a gradual shift away from fossil fuels without doing away with the latter altogether.

The opposition to biofuels on the part of environmental groups and other organisations such as green parties or churches is an interesting analytical feature of biofuel promotion policies. However, it should be noted that this opposition has not materialised evenly. Biofuels remain uncontroversial in some countries (e.g. Brazil), while in others sustained opposition—coupled with a lack of demand—has discouraged policymakers from promoting them (e.g. Germany). In the following analysis, rather than discussing in detail the public acceptance of biofuels, we will concentrate on the motivations of governments for adopting and/or maintaining them.

3 The Empirical Puzzle

A rich literature exists on the subject of biofuels, and making a novel contribution to it requires a fresh angle. In our view, such a perspective should be comparative, taking markedly different countries into account. Moreover, it needs to differentiate between the various generations of biofuels and investigate whether they are part of a broader political agenda for innovation (e.g. for the bioeconomy).

The empirical focus of our analysis is therefore on the sub-Saharan African states of Mali, Mozambique, Nigeria, and Senegal; Brazil and Argentina in South America; Indonesia, Japan, and Thailand in Asia; Denmark, Lithuania, Portugal, and Russia in Europe; and Mexico and the US in North America. According to the German Bioeconomy Council (2015a, b, 2018), these countries have all adopted policies that promote biofuels.[1]

Collectively, these states are characterized by marked disparities in their respective levels of economic development and vulnerabilities in terms of energy supply security, alongside numerous other differences ranging from their political regimes and degrees of integration within international (energy) markets to their various roles in global climate and energy politics—featuring both leaders and laggards alike. This begs the question: why have these diverse countries all adopted a seemingly similar policy approach toward biofuels?

Table 17.1 underscores the differences in these states' levels of socio-economic development as indicated by their gross domestic product per capita (GDP p.c.) in US$ dollars, the importance of agriculture nationally (measured as a share of GDP), and key energy statistics. The latter include petroleum production, biofuel production, and membership in the International Energy Agency (IEA), Organisation of Petroleum Exporting Countries (OPEC), and International Renewable Energy Agency (IRENA).

We can infer from the table above that the GDP per capita varies drastically between these countries, with the US being the most and Mozambique the least affluent country. Denmark and Mali, meanwhile, constitute the country pair featuring the most notable differences with regard to the importance of agriculture (as measured by the sector's share of GDP). In our country sample, the US is by far the biggest producer of petroleum, followed by Brazil and Mexico. When analysing the volume of biofuels produced, we can see that the largest producers are the US and Brazil, followed by Argentina and Indonesia—with a significant gap in between.

Turning to membership of energy-related intergovernmental organisations, we can see that the more affluent countries in our set belong to the IEA. This observation is not surprising, given that IEA membership is conditional on membership of the Organisation for Economic Cooperation and Development (OECD). The empirical patterns observed here, therefore, appear plausible. Of the states included in this analysis, only Nigeria is an OPEC member. OPEC membership is conditional, as with the IEA, but not on the level of

[1] We have centered our analysis on countries that have adopted a specific policy framework on biofuels-bypassing those that have pursued renewable energy policies generally. In our view, this focused approach is more appropriate for singling out states that are particularly committed to biofuels, since otherwise they would not have adopted a specific legal framework for promoting biofuel production.

Table 17.1 Key (energy) statistics for the countries analysed

Country	World Region	GDP p.c. (2010 constant US$; 2016)	Agriculture (% GDP; 2016)	Petroleum (bbl/ds per year; 2016)	Biofuels (1000 metric tons per year; 2016)	IEA membership (yes/no)	OPEC membership (yes/no)	IRENA membership (yes/no)
Mali	Africa	779.9	42.1	0	0	No	No	Yes
Mozambique	Africa	382.1	24.8	0	8.7	No	No	Yes
Nigeria	Africa	2,175.7	21.2	48	0	No	Yes	Yes
Senegal	Africa	952.8	17.5	0	0	No	No	Yes
Indonesia	Asia	3,570.3	14	832	3,208	No	No	Yes
Japan	Asia	38,972.3	1.2	8	16	Yes	No	Yes
Thailand	Asia	5,910.6	8.3	199	1,007	No	No	Yes
Denmark	Europe	53,578.8	0.9	141	151	Yes	No	Yes
Lithuania	Europe	14,912.7	3.3	2	104	No	No	Yes
Portugal	Europe	19,871.7	2.2	0	0	Yes	No	Yes
Russia	Europe	11,279.6	4.2	10,551	457	No	No	Yes
Mexico	North America	8,208.6	3.8	2,187	19	Yes	No	Yes
United States	North America	57,638.2	1.1 (2015)	3,509	44,755	Yes	No	Yes
Argentina	South America	12,440.3	7.6	511	3,156	No	No	Yes
Brazil	South America	8,649.9	5.5	2,515	24,422	No	No	In accession

Sources: German Bioeconomy Council (2015a, 2015b, 2018), World Bank (n.d.), US Energy Information Administration (2019), IEA (2019), OPEC (2019) and IRENA (2019) socio-economic development. Instead, countries seeking to join OPEC must produce and export petroleum. Very little cross-country variation can be detected for membership of IRENA, which represents the most recently created intergovernmental organisation working on energy issues (see Van de Graaf, 2013; Urpelainen and Van de Graaf, 2015). All of the states analysed here either are existing members of IRENA or are in the process of joining it.

In sum, we can conclude that we are dealing with a markedly heterogeneous group of countries. The statistics for certain states in Table 17.1, for example, suggest that biofuels constitute a hitherto untapped area for potential economic development (i.e. in Africa). In the case of others, the importance of petroleum—and fossil fuels more generally—for the economy and transport sector in particular could be the reason driving adoption of biofuel promotion policies. Alternatively, the implementation of a more ambitious innovation program could also lead governments to promote biofuels. In the following sections we will examine the biofuel strategies adopted by these countries in detail, in order to provide an explanation for the empirical similarities observed between them.

4 Sub-Saharan Africa: Launching First-Generation Biofuels

In recent years, sub-Saharan African countries have implemented a number of biofuel promotion policies. According to the German Bioeconomy Council (2018: 23), the four states that have adopted specific policies on biofuels are Mali, Mozambique, Nigeria, and Senegal. As the potential for producing ethanol (from sugarcane) is limited in Mozambique and Nigeria, these countries have instead pursued the production of biodiesel from Jatropha—an oil-bearing, non-edible tree that can withstand droughts and is suitable for both small- and large-scale cultivation (Favretto et al., 2015: 37). While Mali and Senegal possess suitable raw materials for bioethanol production (Dianka, 2012), they have likewise sought to primarily incentivize the cultivation of Jatropha.

Biofuels first appeared on Mozambique's political agenda in 2005, when incoming president Armando Guebuza took the lead in advocating for the cultivation of Jatropha. In 2009, the country's parliament adopted the National Biofuels Policy and Strategy with a view to increasing energy security by replacing imported fossil fuels with domestically produced biofuels. The policy was also aimed at fostering economic growth and stimulating employment in the agricultural sector (German Bioeconomy Council, 2015a: 21). Its adoption was further informed by a study evaluating the expected costs and benefits of developing biofuels in Mozambique, which at the time were not produced in the country (Di Lucia, 2010: 7398). The 'evidence-based' approach here is rather remarkable and indicates that the introduction of this policy was carefully prepared. In 2013, the Mozambican government proposed a framework for applying sustainability criteria to the production of biofuels in order to avoid conflicts over land use and ensure food security (German Bioeconomy Council, 2015a: 20). The adoption of these criteria can be linked to the sustainability system of EU Directive 2009/30/EC and the government's desire to comply with these requirements, as the EU represents an attractive export market for biofuels (Di Lucia, 2010; Schut et al., 2014).[2]

Nigeria committed itself to the promotion of biofuels around the same time, adopting the Nigerian Biofuels Policy and Incentives in 2007 (German Bioeconomy Council, 2015a: 24). The country's embrace of biofuels is perhaps surprising, given its position as a major oil-producing nation. Indeed, the policy in question—aimed primarily at promoting first-generation biofuels—has a number of different goals. Prominent among these is ensuring energy security and addressing economic and environmental concerns. The country currently depends on imports of refined petroleum products, and these could be replaced by domestically produced biofuels. Meanwhile, one concerning consequence of Nigeria's large petroleum industry has been a high level of environmental degradation. In this context, biofuels are seen as a means of curbing pollution. Diversifying the national economy and exploiting new potential for agri-industrial development represent further motivations (Abila, 2012: 338), and the policy framework also seeks to attract foreign investors to Nigeria (German Bioeconomy Council, 2015a: 25).

In contrast to its West African counterpart, Mali—like Mozambique—is one of the poorest countries in the world. Its government initiated a general policy on bioenergy in 2006, and in 2008 a specific one on the promotion of biofuels (German Bioeconomy Council, 2015a: 16). Numerous considerations shaped the government's decision to embrace biofuels, including the reduction of national fossil fuel consumption—to decrease the country's high dependence on petroleum imports—the encouragement of low-carbon economic growth, and poverty alleviation (Favretto et al., 2015: 40). Since 2011, the United Nations Development Program, with the financial assistance of

[2] Directive 2009/30/EC amends Directive 98/70/EC with regard to the specification of petrol, diesel, and gas-oil and introduces a mechanism to monitor and reduce greenhouse gas emissions.

the Global Environment Fund, has supported the creation of regulatory and institutional frameworks for the development of biofuels, which in Mali are also based on Jatropha feedstock (German Bioeconomy Council, 2015a: 17). According to Favretto et al. (2015: 52), biofuel development policies in the country are supported by NGOs and the "*mainstreaming of internationally agreed principles into national policies is key to attract monetary, institutional and technical support from international organisations and donors*".

Senegal likewise began promoting biofuel production in 2006, providing support for the cultivation of the Jatropha tree (German Bioeconomy Council, 2015a: 26). As with the other sub-Saharan states discussed in this chapter, the country regards biofuels as a means of reducing its dependence on imported fossil fuels and as a tool for agricultural modernisation and sectoral job creation (Dianka, 2012). With the creation of the National Agency for Renewable Energy in 2013, the Senegalese government further institutionalized the promotion of biofuels and renewable energy more generally (German Bioeconomy Council, 2015a: 26).

In sum, the promotion of first-generation biofuels in sub-Saharan Africa stems from security, economic, and—to a certain extent—environmental considerations. Overall, the potential for economic growth resulting from the EU's embrace of biofuels appears to be the main trigger for the African policies promoting them (see Di Lucia, 2010; Dianka, 2012; Schut et al., 2014). International organisations and donors have also played an influential role, providing countries with the funding required for modernising their agriculture and developing biofuels. From this perspective, the promotion of biofuels constitutes an attempt by the aforementioned states to take advantage of the opportunity structure provided by international markets.

5 Asia: Innovation Versus Energy Supply Security

Indonesia, Japan, and Thailand represent a remarkably heterogeneous country cluster, both in terms of the type of biofuels promoted and their respective characteristics with regard to energy. Indonesia and Thailand, for example, favor palm oil-based biodiesel, with the former being the world's largest producer of palm oil (Mukherjee and Sovacool, 2014: 7). Japan, by contrast, can be said to exhibit a more sophisticated approach to biofuels, viewing them as part of a broader innovation agenda.

Once a significant oil exporter, in the early 2000s Indonesia had to revise its energy strategy when national extraction slowed down. This resulted in the National Security Act (2006), which called for the diversification of the country's energy supply and the implementation of a number of regulations supporting biofuel development (Mukherjee and Sovacool, 2014: 7). In line with this approach, the government updated the National Energy Policy in 2014 and the following year adopted its Grand Agricultural Strategy (German Bioeconomy Council, 2018: 50). That these acts came to define Indonesia's overall policy framework in this area is indicative of wider biofuel promotion trends, in which considerations of energy (security) and agricultural development both play an important role.

Of the different types of bioenergy, biofuels represent a national priority area. Their use is promoted through blending mandates for fossil fuels intended for industrial production, transportation, and electricity production (German Bioeconomy Council, 2015a: 67). These mandates have been further bolstered by subsidies. The main reason for the government's promotion of biofuels is the perceived need to replace fossil fuels (which would need to be purchased on the international market) with domestically produced fuels. However, Indonesia's use of palm oil for biodiesel production has been severely criticized in Western countries (see Mukherjee and Sovacool, 2014). As a result, the Indonesian government has paid increased attention to issues related to the sustainability of biofuel production, for example by developing the Sustainable Palm Oil Standard (German Bioeconomy Council, 2015a: 67).

Thailand is another major producer of palm oil, and the country has likewise supported the production and consumption of palm oil-based biodiesel. Its motivation in this regard parallels that of Indonesia: given the ready availability of palm oil, the production of biodiesel is considered an attractive strategy for enhancing energy supply security and boosting rural development and job creation (Mukherjee and Sovacool, 2014: 9). The central policy framework in this area is the Alternative Energies Development Plan, which covers the period from 2012 to 2021 (German Bioeconomy Council, 2018: 50).

That said, one key aspect distinguishes the respective approaches adopted by these two Southeast Asian states: Thailand, unlike Indonesia, does not regard (first-generation) biofuels as the end goal of its policy, but rather as a starting point. In this vein, the nation has adopted a holistic bioeconomy strategy with the aim of benefitting from technology transfers and foreign investment (German Bioeconomy Council, 2015a: 83). The Thai government's support for biofuels has thus opened up new opportunities for developing a high-technology industry in the country based on biological inputs.

Japan, meanwhile, has a clear incentive for promoting biofuels, heavily dependent as it is on imported raw materials and fuels. Indeed, the nation is one of the largest energy importers in the world and suffers from high energy prices in industrial production (Lim and Lee, 2012). Ensuring energy supply security and finding ways to reduce energy prices therefore constitute key priorities for the government. Despite these vulnerabilities, Japan does not have a single unified strategy for biofuel promotion. Instead, it has several national strategies and plans such as the Biomass Nippon Strategy. Approved in 2002, this constitutes the first of the aforementioned initiatives and is aimed at mitigating climate change, incubating new industry, and strengthening rural economies (Matsumoto et al., 2009: S70). While the government has adopted blending rates, it does not make use of subsidies or price controls but rather focuses on tax-related measures to address price differences between fossil fuels and biofuels (Matsumoto et al., 2009: S71).

The Japanese biofuel strategy can thus be characterized as containing several elements, with a strong emphasis on the development of second-generation biofuels. From this perspective, Japan stands out even more than Thailand as a country that views biofuels as one of many components in an overall bioeconomy strategy (German Bioeconomy Council, 2015a: 38). Once again, it is the country's great dependence on fuel imports that has led the government to invest in improving biofuel-related technology, since any efficiency gains will have positive implications for Japan's manufacturing sector (Lim and Lee, 2012: 1791).

As demonstrated in this section, the three countries analyzed have pursued markedly different biofuel promotion strategies. While Indonesia regards first-generation biofuels as the final product of its policy, Thailand and in particular Japan consider biofuels as being in need of further improvement to render them more efficient—and valuable—for their economies. The divergent perspectives of Indonesia, on the one hand, and Thailand and Japan, on the other, are especially interesting given that the trigger for biofuel promotion in Indonesia was similar to that in Japan: namely, the high cost of energy imports from abroad. That said, Thailand is perhaps the most surprising case study of the three, as the country has less experience with developing a high-technology industry but has nevertheless proved willing to pursue that pathway. The Japanese approach, by contrast, is not as surprising considering the high demand for biofuels nationally, the existence of advanced technology for producing them locally, and the generally excellent research facilities in the country (see Lim and Lee, 2012: 1793).

6 Europe: Innovating for Sustainable Biofuels

The next country cluster consists of three EU member states and Russia. Within this group, Denmark's present stance on biofuels might be the most surprising, given that it initially disapproved of the EU's approach to biofuel promotion—with the Danish government demonstrating an early unwillingness to comply with EU Directive 2003/30/EC (Di Lucia and Kronsell, 2010). Since then, however, the nation has adopted the Growth Plan for Water, Bio and Environmental Solutions (2013), which seeks to exploit the potential of the agricultural sector for the production of biomass. Indeed, Denmark now considers this area a "*future market for Danish technology suppliers*" (German Bioeconomy Council, 2015a: 91).

In marked contrast to Denmark, Lithuania was among the first EU member states to comply with EU Directive 2003/30/EC (Tosun and Schulze, 2015). It is therefore less surprising that the Lithuanian government continues to support biofuels. However, as is the case with Denmark today, Lithuania has done so with a view to modernizing its economy. Specifically, policymakers in the country regard biofuels as one element of the National Industrial Biotechnology Development Program, which seeks to make use of biotechnology in order to produce second-generation biofuels (German Bioeconomy Council, 2015a: 104). When it comes to biofuels, this aligns with the strategic interests of Danish policymakers: namely, they are seen as a market for innovative technologies. At the same time, the goals of reducing fossil fuel dependence and increasing resource efficiency also play a role in the Danish approach (German Bioeconomy Council, 2015a: 104).

A similar observation can be made in the case of Portugal and its National Ocean Strategy, which covers the period from 2013 to 2020. With this policy, the Portuguese government seeks to harness the 'blue economy' in order to develop algae as a feedstock for the production of biofuels (German Bioeconomy Council 2015a: 113). This approach is particularly interesting, as it seeks to offer a solution to the land use issue that has dogged biofuel producers (see Pilgrim and Harvey, 2010). Moreover, it likewise demonstrates how governments are endeavoring to exploit the economic potential represented by second-generation biofuel development. At its core, the Portuguese policy is aimed at modernising the country's economy and generating employment.

On the other side of Europe, Russia—not an EU member state—has also embraced biofuels. In 2012, its government adopted the Comprehensive Program for the Development of Biotechnology in the Russian Federation

Through 2020, along with a corresponding implementation roadmap in 2013. Paralleling the other countries analysed so far, Russia regards biofuels as an innovation area and has sought to take advantage of their potential, with an eye to improving the efficiency and sustainability of biofuel production. More precisely, the Russian strategy aims to use agricultural biotechnology to increase the production of biomass and produce second-generation biofuels (German Bioeconomy Council, 2015a: 75). Considerations of energy dependence do not play an important role in the country's biofuel strategy. Rather, the government is eager to stimulate rural development and create employment in the agri-industrial sector.

7 North America: First and Second Movers

We now turn to the US and Mexico, the two North American countries that have supported biofuels, but which differ in their respective approaches to biofuel production. The United States—the 'first mover'—is a particularly special case, as it produces biofuels from corn and has also overtaken Brazil as the largest producer in the world (Chen and Khanna, 2013: 290).

Indeed, the US policy is especially interesting when it comes to biofuels, as the country has pursued a dual approach in this area. On the one hand, the government continues to promote first-generation biofuels by means of the Biorefinery Assistance Program. This initiative is administered by the US Department of Agriculture's Rural Development agency, and offers loan guarantees for the development, construction, and retrofitting of commercial-scale biorefineries.[3] On the other hand, the government has embraced an ambitious agenda for the development of modern biofuels for the transport sector, in order to develop an innovation market and become a leader in the production of these new biofuels (German Bioeconomy Council, 2018: 43). In other words, there is coexistence between both traditional and modern approaches to biofuels in the US policy framework. This dual strategy is a response to multiple issues, the first being the perceived need to continue supporting farmers and the agrarian sector, and the second relating to general economic growth and the development of a high-technology industry. Motivating both aspects of this strategy is the country's desire to diversify its energy mix and rely more heavily on domestic energy sources.

Mexico, meanwhile, has also committed itself to the development of biofuels with the adoption of its National Development Plan, covering the period

[3] For more information, see the US Department of Energy (n.d.).

from 2006 to 2012. This was cemented with the approval of the Law on the Promotion of Bioenergy in 2008, and the subsequent Inter-Secretarial Strategy on Bioenergy in 2009. Underlying this approach was the government's determination to diversify the country's energy mix (German Bioeconomy Council, 2015a: 46). Interestingly, the Mexican government—as a 'second mover'—is aware of the sustainability issue linked to the production of biofuels, and has adopted a high-technology approach in response. In other words, the country is seeking to develop second-generation biofuels. As a consequence, the government has been willing to invest in research and development (R&D) while responding positively to calls for the incorporation of sustainability criteria into biofuel production (German Bioeconomy Council, 2015a: 47). Considering the importance of corn for the Mexican diet, and the sharp increase in corn prices experienced by the country in 2007 (de Gorter et al., 2013: 84), the emphasis on sustainability in Mexico's approach in this area makes sense. However, the policy's focus on newer generation biofuels is also motivated by the government's push to create more jobs. As a result, the Mexican biofuel strategy pays attention to issues related to energy security, food security, and economic development potential (German Bioeconomy Council, 2015a: 46–47).

8 South America: The Nexus Between Biofuels and Biotech Crops

Brazil has a long-standing tradition of supporting biofuels. Commencing in 1975 with its Proálcool Program, the country has become one of the largest producers of ethanol (based exclusively on sugarcane) and has exported to both the EU and US (Chen and Khanna, 2013). The government currently has two major initiatives in place to support biofuels: one that concentrates on the promotion of ethanol production, and the other on biodiesel. The latter is produced on the basis of soy, which has been an important agricultural commodity in the country since the 1980s. In this context, it is also important to mention that Brazil has cultivated genetically modified crops in order to further increase yields (Tosun, 2013).

The country is not only the leader in ethanol production, but also in terms of consumption. During the 1990s, the share of ethanol-fueled cars was low, but rising petroleum prices led motorists to purchase fuel-flex cars. Today, high demand for ethanol and fuel-flex vehicles—coupled with Brazil's need to comply with its climate mitigation commitments—has led the government to continue pursuing biofuels (Wilkinson and Herrera, 2010). In this vein, it has relied on a remarkably holistic strategy when it comes to biofuel promotion. In addition to encouraging the development of ethanol and biodiesel through the provision of financial support to producers, the government has also invested in filling stations that offer biofuels and proactively steered demand by making use of blending quotas. This is a dual approach in the sense that it promotes first-generation biofuels on the one hand, and on the other furthers investments in R&D with the goal of inventing second-generation biofuels based on sugarcane (German Bioeconomy Council, 2015a: 41).

Another leader in the production of biofuels—specifically biodiesel—is Argentina. As with Brazil, Argentina also cultivates genetically modified crops and is a major exporter of agricultural commodities (Tosun, 2013). Despite the country's strong sectoral position in international markets, it has sought to pursue biofuels for their economic growth potential. While the Argentine government has also endeavored to improve the quality and efficiency of biofuels by investing in R&D, unlike its Brazilian counterpart it views biofuels as one of several components in a comprehensive bioeconomy strategy. In this vein, the Argentina Innovadora 2020 initiative clearly demonstrates the nation's willingness to foster technological innovation, although biofuels do not play as central a role in it—in stark contrast to the parallel scheme in Brazil. Nevertheless, the starting point for the country's ambitious agenda aimed at achieving a bio-based economy was the government's support for biofuels (German Bioeconomy Council, 2015a: 38).

Despite their agricultural similarities, Argentina and Brazil have thus adopted different policies for the promotion of biofuels. The Brazilian strategy corresponds to that of the US, as it combines a conservative approach with innovations. Argentina, by contrast, regards biofuels as one component of a more comprehensive agenda for fostering technological innovation—a notable distinction.

9 Interdependence, Harmonisation, and the Future of Biofuels

The objective of this chapter has been to solve the empirical puzzle described earlier—namely, why a diverse group of countries decided to adopt similar policies aimed at promoting biofuels. The first part of the solution to this puzzle lies in the fact that the analyzed states have varied to a significant extent in the type of biofuels they chose to promote. In less- and least developed countries, the policy strategy has been focused on first-generation biofuels, whereas in developed countries second- and third-generation biofuels have been at the center of attention. In this context, the case of Thailand is particularly intriguing, since—despite the country's status as a transition economy—its government has regarded biofuels as a stepping stone to a more ambitious policy agenda for the bioeconomy. The Thai government has thus approached biofuels as an innovation area, and sought to benefit from technology transfers and foreign direct investment.

We could also observe developed countries paying renewed attention to biofuels, as these provide a means of attaining multiple goals at once. Biofuels support and sustain a trajectory in which fossil fuels still play a central role, but offer the possibility of curbing carbon emissions—despite constant levels of road traffic, agri-industrial development, and economic growth—while also enhancing energy supply security. Furthermore, with the emergence of the bioeconomy as a new economic agenda, biofuels have received even greater attention as an area of extensive innovation potential.

Turning to the explanation of policy similarities, we have followed the framework on policy convergence put forward by Holzinger and Knill (2005), who distinguish between imposition, international harmonisation, regulatory competition, and transnational communication. Imposition occurs whenever an external political actor forces a government to adopt a certain policy. Policies can either be unilaterally imposed on a country by another, or the imposition can occur by way of conditionality on the part of an international institution. Harmonisation refers to a situation in which (member) states voluntarily engage in international cooperation. This mechanism implies that countries comply with uniform legal obligations defined in international or supranational law. Regulatory competition is expected to homogenise the policy outputs of countries when they are mutually faced with competitive pressures, but economic integration can also affect policy-making in a different form. Countries that regulate highly are able to induce stricter standards if they can erect exceptional trade barriers—due to health or environmental concerns, for example (Vogel, 1995).

Transnational communication, meanwhile, consists of a number of mechanisms that are based purely on communication among countries: namely, lesson-drawing, transnational problem-solving, emulation, and the transnational promotion of policy models (Holzinger and Knill, 2005). Lesson-drawing refers to constellations of policy transfers in which governments rationally utilize available experience elsewhere in order to solve domestic problems. Transnational problem-solving is also based on rational learning, while emulation is motivated by the desire for conformity with other countries rather than the search for effective solutions to given problems. Policy adoption, by contrast, can be driven by the active role of international institutions such as the World Bank.

In this context, the empirical pattern observed in the present analysis can be explained by independent problem-solving, policy harmonisation, and diffusion. In the case of the US, for example, the promotion of biofuels was motivated by the desire to offer a source of stable income to farmers and decrease the nation's dependence on imported fuels (Kay and Ackrill, 2012; Khanna and Chen, 2013). For the EU, harmonisation explains why all member states had to position themselves as they did on biofuels. In some countries, the EU's call for biofuel promotion has resulted in a significant policy shift. Originally opposed to the EU biofuel policy, the Finnish approach changed completely in 2011 when domestic forestry companies became interested in developing technologies to produce biodiesel from wood-based feedstock (Lovio and Kivimaa, 2012: 785). In other EU states, biofuels are subject to sustained criticism by environmental groups, and there is low demand for them as a result. In those places, this has served to reduce the economic attractiveness of biofuel-based products such as fuel blends. A case in point is Germany, where the demand for ethanol-petroleum blends has consolidated at the level of about 15% (Tosun, 2018a, b).

In this context, it is important to note that the harmonisation of biofuel policies at the EU level has also had implications for countries located within the broader neighborhood of the bloc, and/or which seek to become members of it. In this way, the Energy Community has facilitated the transfer of these and other energy-related policies to non-member states. Furthermore, Tosun and Schulze (2015) have shown that nations with a strong agrarian lobby are more likely to adopt the EU's policy on biofuels compared to countries that do not possess such interest mediation structures.

While the promotion of biofuels in the EU's neighborhood can be explained by cooperation mechanisms and the existence of the Energy Community—which seeks to 'export' the EU's policy arrangements to third states—the motivation for non-European third states is different. As the discussion of policy adoption in the African countries has shown, the EU's decision to collectively embrace biofuels has created an economic incentive for the former to seize that economic opportunity. Echoing the argument put forth by Vogel (1995), the characteristics of the EU market have induced these non-European nations to produce biofuels both for export as well as for domestic use. The growing attention paid by these governments to sustainability-related issues further supports the notion that the EU's embrace of biofuels has triggered policy change in these other countries. Research on Mozambique provides a strong supporting case for this argument (e.g. Di Lucia, 2010), as does the example of Indonesia. Indeed, the Indonesian government's attempts to pay greater attention to sustainability suggest that the EU's internal market has provided an incentive for biofuel development in that country. From this perspective, there is a considerable degree of interdependent decision-making with regard to biofuels around the world.

10 Conclusion

The academic discussion surrounding biofuels has typically focused on sustainability issues related to their production. In that vein, studies have concentrated on the determinants relating to the public acceptance of biofuels. In most countries, the use of biofuels—predominantly in the form of fuel blends—is a voluntary decision taken by consumers (Tosun, 2018a, b), with the state incentivising consumer demand by means of subsidies or other instruments. From that viewpoint, it is a meaningful exercise to examine the determinants of biofuel acceptance.

That said, the case of biofuels is instructive beyond aspects related to acceptance. As has been demonstrated in the present chapter, we have witnessed how biofuel promotion policies have diffused globally across countries with markedly different characteristics. In each of the cases analysed, biofuels are not intended as a complete substitute for fossil fuels. The policies adopted mean to increase the quantity of biofuels used, thereby reducing the overall share of fossil fuels. While the types of biofuels promoted are not identical, decisions to adopt such policies have been interdependent. In the EU and the US, the promotion of biofuels represents an attempt to pursue multiple goals at the same time: namely, increasing energy security, decarbonising the transportation and energy sectors, and promoting agri-industrial development. As these important markets have decided to promote biofuels, they have in turn created an economic incentive structure for developing countries in particular, which have embraced biofuels accordingly.

In this vein, the policy decisions made by more affluent countries have clearly affected the policy decisions of less affluent ones, with the economic incentive structure explaining the similarities observed. Some of the states analysed consider such economic incentives to be limited to the exportation of first-generation biofuels. Others, by contrast, have demonstrated an eagerness to be a part of a broader, global movement aimed at realising the bioeconomy agenda and the attendant technology transfers accompanying it. In both cases, the poorer countries have embraced biofuel promotion policies. An additional yet also important factor is the role of international organisations and foreign donors in developing countries, as these actors provide valuable assistance for initiating the cultivation of plants and crops suitable for the production of biofuels.

Overall, we can confirm that harmonisation is the key explanation in the case of EU member states and other nations in the bloc's neighborhood. Turning to developing countries, economic incentives and the promotion of this particular policy agenda by foreign donors and international organisations have played a key role. For developed countries, meanwhile, the promotion of biofuels is either an independent response to a problem (i.e. dependence on fuel imports) or the result of positive lessons learned from other states that have experimented with biofuel promotion.

Regardless of the mechanisms bringing about cross-country policy similarities, biofuels are likely to remain on the political agenda of many nations. The main reasons for this are the innovation potential of biofuels—as a component of the comprehensive agenda for achieving a bioeconomy, for example—and their prospects for stimulating economic growth. In poorer states in particular, these are sufficient grounds for governments to continue supporting them.

Finally, a more general insight revealed by our analysis is that, despite the marked differences between the various countries examined here, the need to align multiple goals has motivated them to adopt relatively similar policy solutions. This is an important finding, as it demonstrates that advanced market economies are, to some extent, in the same early stages as developing and transition economies when it comes to their policy ideas for addressing challenges such as climate change.

References

Abila, N. 2012. Biofuels Development and Adoption in Nigeria: Synthesis of Drivers, Incentives and Enablers. *Energy Policy* 43: 387–395.

Ackrill, R. and Kay, A. 2014. *The Growth of Biofuels in the 21st Century: Policy Drivers and Market Challenges*. London: Palgrave Macmillan.

Balat, M. 2007. An Overview of Biofuels and Policies in the European Union. *Energy Sources, Part B: Economics, Planning, and Policy* 2(2): 167–181.

Chen, X. and Khanna, M. 2013. Food vs. Fuel: The Role of Biofuel Policies. *American Journal of Agricultural Economics* 95(2): 289–295

Bomb, C., McCormick, K., Deurwaarder, E. and Kåberger, T. 2007. Biofuels for Transport in Europe: Lessons from Germany and the UK. *Energy Policy* 35(4): 2256–2267.

de Gorter, H., Drabik, D. and Just, D.R. 2013. How Biofuels Policies Affect the Level of Grains and Oilseed Prices: Theory, Models and Evidence. *Global Food Security* 2(2): 82–88.

Demirbas, M.F. and Balat, M. 2006. Recent Advances on the Production and Utilization Trends of Bio-Fuels: A Global Perspective. *Energy Conversion and Management* 47(15/16): 2371–2381.

Di Lucia, L. 2010. External Governance and the EU Policy for Sustainable Biofuels, the Case of Mozambique. *Energy Policy* 38(11): 7395–7403.

Di Lucia, L. 2013. Too Difficult to Govern? An Assessment of the Governability of Transport Biofuels in the EU. *Energy Policy* 63: 81–88.

Di Lucia, L. and Kronsell, A. 2010. The Willing, the Unwilling and the Unable–Explaining Implementation of the EU Biofuels Directive. *Journal of European Public Policy* 17(4): 545–563.

Di Lucia, L. and Nilsson, L.J. 2007. Transport Biofuels in the European Union: The State of Play. *Transport Policy* 14(6): 533–543.

Dianka, M. 2012. Promoting Biofuels in West Africa: An Engine for Development. In: Janssen, R. and Rutz, D. (Eds.) *Bioenergy for Sustainable Development in Africa*. Dordrecht: Springer, pp. 201–207.

Eikeland, P.O. 2006. *Biofuels—The New Oil for the Petroleum Industry?* Lysaker: Fridtjof Nansen Institute.

Favretto, N., Stringer, L.C. and Dougill, A.J. 2015. Towards Improved Policy and Institutional Coherence in the Promotion of Sustainable Biofuels in Mali. *Environmental Policy and Governance* 25(1): 36–54.

Friends of the Earth (FoE). 2013. *Don't Be Fooled by Biofuels*. London: Friends of the Earth.

German Bioeconomy Council. 2015a. *Bioeconomy Policy (Part II): Synopsis of National Strategies Around the World*. Berlin: German Bioeconomy Council.

German Bioeconomy Council. 2015b. *Bioeconomy Policy: Synopsis and Analysis of Strategies in the G7*. Berlin: German Bioeconomy Council.

German Bioeconomy Council. 2018. *Bioeconomy Policy (Part III): Update Report of National Strategies Around the World*. Berlin: German Bioeconomy Council.

Henke, J.M., Klepper, G. and Schmitz, N. 2005. Tax Exemption for Biofuels in Germany: Is Bio-Ethanol Really an Option for Climate Policy? *Energy* 30(14): 2617–2635.

Holzinger, K. and Knill, C. 2005. Causes and Conditions of Cross-National Policy Convergence. *Journal of European Public Policy* 12(5): 775–796.

International Advisory Council of the Global Bioeconomy Summit. 2015. Communiqué. http://gbs2015.com/fileadmin/gbs2015/Downloads/Communique_final.pdf

International Energy Agency. 2019. The IEA Is the Global Energy Authority. https://www.iea.org/

IRENA. 2019. About Us. https://www.irena.org/

Kay, A. and Ackrill, R. 2012. Governing the Transition to a Biofuels Economy in the US and EU: Accommodating Value Conflicts, Implementing Uncertainty. *Policy and Society* 31(4): 295–306.

Khanna, M. and Chen, X. 2013. Economic, Energy Security, and greenhouse Gas Effects of Biofuels: Implications for Policy. *American Journal of Agricultural Economics* 95(5): 1325–1331.

Levidow, L. 2013. EU Criteria for Sustainable Biofuels: Accounting for Carbon, Depoliticising Plunder. *Geoforum* 44(1): 211–223.

Lim, S. and Lee, K.T. 2012. Implementation of biofuels in Malaysian transportation sector towards sustainable development: A case study of international cooperation between Malaysia and Japan. *Renewable and Sustainable Energy Reviews* 16(4): 1790–1800.

Lovio, R. and Kivimaa, P. 2012. Comparing Alternative Path Creation Frameworks in the Context of Emerging Biofuel Fields in the Netherlands, Sweden and Finland. *European Planning Studies* 20(5): 773–790.

Matsumoto, N., Sano, D. and Elder, M. 2009. Biofuel Initiatives in Japan: Strategies, Policies, and Future Potential. *Applied Energy* 86: S69–S76.

McCormick, K. and Kautto, N. 2013. The Bioeconomy in Europe: An Overview. *Sustainability* 5(6): 2589–2608.

McCormick, K., Bomb, C. and Deurwaarder, E. 2012. Governance of Biofuels for Transport in Europe: Lessons from Sweden and the UK. *Biofuels* 3(3): 293–305.

Mukherjee, I. and Sovacool, B.K. 2014. Palm Oil-Based Biofuels and Sustainability in Southeast Asia: A Review of Indonesia, Malaysia, and Thailand. *Renewable and Sustainable Energy Reviews* 37: 1–12.

Naik, S.N., Goud, V.V., Rout, P.K., and Dalai, A.K. 2010. Production of First and Second-Generation Biofuels: A Comprehensive Review. *Renewable and Sustainable Energy Reviews* 14(2): 578–597.

OPEC. 2019. Home. www.opec.org

Pilgrim, S. and Harvey, M. 2010. Battles Over Biofuels in Europe: NGOs and the Politics of Markets. *Sociological Research Online* 15(3): 1–16. https://doi.org/10.5153/sro.2192.

Rauch, A. and Thöne, M. 2012. Biofuels—At What Cost? Mandating Ethanol and Biodiesel Consumption in Germany. https://www.iisd.org/gsi/sites/default/files/bf_awc_germany.pdf

Schleifer, P. 2013. Orchestrating Sustainability: The Case of European Union Biofuel Governance. *Regulation & Governance* 7(4): 533–546.

Schut, M., Soares, N.C., van de Ven, G. and Slingerland, M. 2014. Multi-actor Governance of Sustainable Biofuels in Developing Countries: The Case of Mozambique. *Energy Policy* 65: 631–643.

Skogstad, G. 2017. Policy Feedback and Self-Reinforcing and Self-Undermining Processes in EU Biofuels Policy. *Journal of European Public Policy* 24(1): 21–41.

Tobin, P., Schmidt, N.M., Tosun, J. and Burns, C. 2018. Mapping States' Paris Climate Pledges: Analysing Targets and Groups at COP 21. *Global Environmental Change* 48: 11–21.

Tolmac, D., Prulovic, S., Lambic, M., Radovanovic, L. and Tolmac, J. 2014. Global Trends on Production and Utilization of Biodiesel. *Energy Sources, Part B: Economics, Planning, and Policy* 9(2): 130–139.

Tosun, J. 2013. *Environmental Policy Change in Emerging Market Democracies: Central and Eastern Europe and Latin America Compared*. Toronto: University of Toronto Press.

Tosun, J. 2017. Energy Policy. In: Thompson, W. (Ed.) *Oxford Research Encyclopedia of Politics*. Oxford: Oxford University Press. https://doi.org/10.1093/acrefore/9780190228637.013.174.

Tosun, J. 2018a. Diffusion: An Outcome of and an Opportunity for Polycentric Activity? In: Jordan, A., Huitema, D., van Asselt, H. and ForsterJ. (Eds.) *Governing Climate Change: Polycentricity in Action?* Cambridge: Cambridge University Press, pp. 152–168.

Tosun, J. 2018b. The Behavior of Suppliers and Consumers in Mandated Markets: The Introduction of the Ethanol-Petrol Blend E10 in Germany. *Journal of Environmental Policy & Planning* 20(1): 1–15.

Tosun, J. and Schulze, K. 2015. Compliance with EU Biofuel Targets in South-Eastern and Eastern Europe: Do Interest Groups Matter? *Environment and Planning C: Government and Policy* 33(5): 950–968.

Urpelainen, J. and Van de Graaf, T. 2015. The International Renewable Energy Agency: A Success Story in Institutional Innovation? *International Environmental Agreements: Politics, Law and Economics* 15(2): 159–177.

US Department of Energy. n.d. USDA—Biorefinery Assistance Program. https://www.energy.gov/savings/usda-biorefinery-assistance-program.

US Energy Information Administration. 2019. Today in Energy. https://www.eia.gov/.

Van de Graaf, T. 2013. Fragmentation in Global Energy Governance: Explaining the Creation of IRENA. *Global Environmental Politics* 13(3): 14–33.

Vogel, D. 1995. *Trading Up: Consumer and Environmental Regulation in the Global Economy*. Cambridge, MA: Harvard University Press.

Wilkinson, J. and Herrera, S. 2010. Biofuels in Brazil: Debates and Impacts. *The Journal of Peasant Studies* 37(4): 749–768.

Wood, G. 2018. Policy Risk, Politics and Low Carbon Energy. In: Considine, J.I. and Paik, K-W. (Eds.) *Handbook of Energy Politics, Cheltenham*. Cheltenham: Edward Elgar Publishing, pp. 425–454.

World Bank. n.d. World Development Indicators. http://datatopics.worldbank.org/world-development-indicators/

18

Re-making the Future: Transition Movements and Dismantling the Environment-Economy Dichotomy

Cassandra Star

1 Introduction

As the global community works towards an end to the fossil fuel era, a clear contestation appears, highlighting both the challenges and the opportunities inherent in a post-carbon world. A post-carbon future, the details of its vision and the paths to get there, create opportunities alternative to the status quo. Thus, at these historical moments, we can observe key political battles for the spoils of transition—existing elites seek to maintain or gain ground, while those disadvantaged within current systems seek to right those injustices. In this chapter, I argue that we can observe existing elites holding onto the power the current economic and energy systems have generated.

The current debates that we observe are about different visions of our economic future and the different values embodied in those visions. Beyond that, these visions have implications for society as a whole and for our current attitudes to economic flourishing. Two competing visions, analysed in this chapter, imply a rejection of the state due to its failure in the domain of climate and carbon constraint policies, but with different outcomes—one embracing the market and the other a return to community.

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I argue that a failure to ensure a *just* transition inevitably leads to entrenching current unjust economic structures and practices. To do so challenges not only the potential emancipatory nature of an historic transition, but also its success. A failure to re-write economic, political and social structures and values will leave embedded earlier assumptions laid down in early state formation, including the environment-economy dichotomy. Unravelling this key feature of contemporary capitalism is essential for a move to a sustainable low carbon future. The key question is whether current transition movements are able to achieve this in a *just* way. A *just* transition would ensure a quicker, more supported move to a post-carbon economy. Recent history is replete with examples of the failure of policies where the absence of broad community support, due to a lack of attention to justice, real or perceived.

In this chapter, firstly, I will introduce the idea of a just transition and explore the key rationales for undertaking or advocating for this pathway. Secondly, I will outline a set of characteristics evident in a just transition. Thirdly, I will outline examples from the two dominant approaches to post-carbon transition appearing in mature liberal democracies. These two approaches will be analysed using a just transition lens. Finally, some key implications for future transition pathways will be highlighted.

2 Why a Just Transition?

A key question to answer initially is, why is a just transition needed—what is to be gained or lost by not securing a just transition? In this section, I argue that a just transition is critical, not just for normative reasons, but also for reasons that are deeply pragmatic, including to ensure successful implementation of any public policy drivers for the transition.

One of the challenges of enabling a just transition is the need to secure widespread acceptance that transition is an economic, political and societal, rather than an individual, imperative. Arguments and calls for transition are inescapably entrenched within our current neoliberal capitalist global context. This has inevitably shaped the discourse(s) of transition, the arguments that can be made and the space available to re-shape the debate. Climate change has shifted from a threat to being understood as an economic opportunity needing an *economic* transition (Janković and Bowman, 2014), rather than a political and societal one. In thus doing, transition can be focussed on the individual and individual responsibilities within transition, abdicating government responsibility not just to drive transition, but also to shape it. This highlights a dilemma of individual change versus broader transformation.

Some approaches to transition manage to engage a space between these two poles. For example, Barr and Pollard (2017: 47) argue that re-localisation approaches to transition "*sit between traditional forms of environmental activism* [seeking major government driven change] *and directive initiatives for individual behaviour change*". A *just* transition necessitates a broader than individual response given the widespread change required and the urgency attributed to the transition.

A significant challenge in any large scale societal change is the need to ensure that the number of "losers" is reduced. This is obviously a normative position, advocating that the burden of costs and the benefits of opportunities be distributed fairly with any major structural change. There are debates in the literature about how fairness in such a situation is defined. Some authors argue that equal sharing of such benefits is appropriate, while others advocate for an equitable sharing, allowing for structural changes to be an opportunity to improve the position of the most disadvantaged in society through redistribution (Klinsky and Dowlatabadi, 2011; Ikeme 2003). However, environmental justice in contemporary struggles also moves beyond these more traditional notions of justice to more radical demands for resistance and revolution (Velicu and Kaika, 2017). Therefore, from either of these positions, the transition required to move to a post-carbon society requires mechanisms to distribute and redistribute both the costs and the benefits to satisfy this normative position.

However, there are reasons, besides normative ones, to seek to reduce 'losers' within the transition to a post-carbon era. These reasons are motivated by calls for 'good policy' as well as societal cohesion. The public policy literature emphasises the crucial need to ensure the 'buy in' of those impacted by policy to ensure its success (for example see May, 2015; Speer, 2012). To secure workable implementation, in a whole range of policy areas, side payments and compensation are needed to ensure that a policy does not face overwhelming resistance from those impacted. Examples of the use of this approach can be found in carbon mitigation policies in both Canada and Australia. In British Columbia (from 2008) and in the Australian national carbon pricing scheme (2012–2014), transfer payments were used to remove the regressive economic impacts on lower socio-economic members of society (Beck et al., 2015; Meng et al., 2013). Such approaches make economic sense—ensuring that money keeps circulating in local economies, avoiding economic contraction and that lower socio-economic communities are not pushed into reliance on the state. However, they are also politically smart, ensuring social legitimacy and reducing the likelihood of backlash against reform, and thus, avoiding implementation failure.

Transition strategies that guard against 'losers' are also important to preserve societal and political cohesion. A key learning of the globalisation transition to a free market global economy of the 1980s and 1990s is the social, cultural and political disaffection of those 'left behind' or economically disadvantaged. In the US, the UK and a number of other countries, the backlash/legacy of this period is asserting itself in the form of populism.

The populist agenda is shaped by not only the material motivations of the economics losers of globalisation, but also by cultural and ideological motivations drawing upon the economic disaffection narrative (Lockwood, 2018). This agenda is significant because right-wing populist politics is likely to be deeply antithetical to the needs of structural transition and the hard choices that it will require. Low-carbon transition will create a new group of economic 'losers' already experiencing difficulty in the global market context—mining communities, energy-intensive industries and intensive agriculture. Right-wing populism, in particular, is deeply anti-environmental, often clothing itself in the trope of the white-male, extractive worker (Hultgren, 2018). We see this phenomenon in both the US under Trump's Presidency, painting himself as friend to coal miners and factory workers. For instance, the 2016 Republican Party platform in the US played upon the insecurities of the white working classes in its "embrace of extractive labour". This has functioned as a powerful symbol used to mobilise other voters, concerned that regulation and cultural change would also disenfranchise them from the American dream. This attempt to re-brand right wing politics as the *vox populi*—is mirrored by the Australian case. Signified by former Prime Minister John Howard's 'battlers' (Brett, 2003, 2005) and recently with Prime Minister Scott Morrison's 2018 bus tour in Northern Queensland, projecting their affinity with the 'ordinary bloke', in this case, coal and gas workers in regional Australia (McDougall, 2018). Similar right-wing populist tropes can be seen to play out in the lead up to Brexit, with those disaffected by economic transformation drawn to discourses about refugees and European migrants causing inflation and unemployment in the United Kingdom (Freeden, 2017; Hobolt, 2016). Thus, the minimisation of workers who lose in any transition is essential.

Therefore, this would suggest the need for inclusive, participatory approaches to transition. To do so, as public policy scholars remind us (see for example May, 2015; Speer, 2012) improves the chances for policy legitimacy, social license and therefore, successful implementation. In addition, such processes are more likely to make transparent who gains from different transition pathways, as well as who gains from the status quo. Entrenched elite interests already have strong relationships and interest management approaches within bureaucracies and political elite circles in liberal democracies. This has been revealed time and again in the work on fossil fuel industry tactics in climate policy debates (Holmes and Star, 2018; Oreskes and Conway, 2010; Pearse, 2009). The use of inclusive and participatory approaches, including, citizen juries, participatory budgeting and digital engagement, does the work to engage and capture the commitment of communities that are significantly impacted in a transition, including extractive industries and carbon-intensive industries. This has shown promise in the literature on deliberative democracy experiments (see example Chilvers and Pallett, 2018; Braun and Könninger, 2018; Laurent, 2016; Binder et al., 2015).

The end of fossil fuels will bring with it a major period of economic transformation and transition. The current global economy is intertwined with fossil fuels to provide energy to drive large scale industrial and extractive industries, but also to underpin the logic of energy intensive production and long-distance global transport required to underpin global consumer markets (Altvater, 2007; Quinn-Thibodeau and Wu, 2016; Wagner et al., 2016). Therefore, the end of fossil fuels will inevitably produce a window of opportunity to at least re-consider, if not transform, current economic, social and political power and practice underpinning the status quo. Any potential transition of this scale is political, despite the policy literature's tendency to assume apolitical, economic considerations alone (for a critique sees Breetz et al., 2018). However, in reality, political alliances and institutional inertia shape the nature of transition and the pathways available (Aghion et al., 2014; Munck af Rosenschold and Rozema, 2014). Incumbent industries and powerful actors resist the costs and implementation of transition. In addition, the distributive politics are significant in transition—while benefits are often communal, costs are often private, unequally distributed and impact already poor or marginalised communities the most.

Thus, discussion of transition and consideration of its nature and consequences inevitably highlights questions of justice. Major economic and social transition has winners and losers to consider, especially where planning for the political reality of transition. Where and how the costs and burdens of transition will be shouldered is a key issue.

The question of justice in the context of transition is one with a long tradition within global social movements. In particular, this idea and the global discourse around it originates from the broad global justice and anti-globalisation movement (Bleiker, 2002; Fotopoulos, 2001) of the 1990s, as well as within the more specific calls of the climate justice movement of the 2000s (Star, 2012; Hall and Star, 2007). Both these movements articulated very specific challenges to the neoliberal global economy and the market as the defining or coordinating mechanism of the distributive costs and benefits of large scale change.

Growing from this broad vision, these movements have articulated strong critiques of the predominant neoliberal environmentalism approach to climate change, embodied within the current Paris Agreement. They specifically challenge this element of the current international regime on climate change. Post-Kyoto, the commitment to historical and distributive justice within the United Nations Framework Convention on Climate Change (UNFCCC) framework has been removed (Ciplet and Roberts, 2017) in favour of the embrace of a market driven approach to emissions reduction that creates a carbon market, replete with new profit opportunities for capital investors (Janković and Bowman, 2014; Boyd et al., 2011).

In contrast, transitional justice movements emphasise the need for a just approach to not only distribution of the burdens, but also the opportunities afforded by the transition away from fossil fuels. This is at odds with the dominant neoliberal environmentalism co-opted and embraced by states and the global political order in the last two decades, created in response to movement demands over climate change. This neoliberal approach emphasises libertarian ideals of justice "*defined as rational pursuit of self-interest between unequal parties*", marketisation and reduction of regulatory structures (Ciplet and Roberts, 2017: 148). Neoliberal environmentalism has also transformed the relationship between the state and citizens: "*individuals have been upheld as agents of change through their ability to exercise greater freedom of choice*" (Barr and Pollard, 2017: 50). The retreat of the state from society, emphasising instead the market and individual responsibility, complicates call for a just transition. How a just transition could be achieved, and who the agents of change would be, becomes a central question given this retreat of the state from environmental regulation.

3 What Does a Just Transition Look Like?

Given what is at stake economically and politically, there is a clear contest over what the low-carbon transition should look like, what levers should be used, how it should be driven, and how governments and other actors should shape it, if at all. Different authors emphasise different aspects of key characteristics of a just transition. I argue that the literature pivots around two key concerns: the equitable sharing of costs and benefits and democratised decision-making.

The equitable sharing of the costs and benefits of the end of fossil fuels is the cornerstone of a just transition. The current literature focusses mainly on the costs, given the potential dislocation caused by major economic change. The particular themes of this cost sharing varies in the literature, with work on energy poverty (Healy and Barry, 2017; Bouzarovski et al., 2016; Newell and Mulvaney, 2013) and the need for proactive support for dislocated workers (Vona, 2019; Stevis and Felli, 2015; Rosemberg, 2010) and extractive communities (Della Bosca and Gillespie, 2018; Johnstone and Hielscher, 2017; Lobao et al., 2016). Thus, a just transition would require a focus on economic justice that cannot be delivered by the market alone and would need intervention to improve equity and to ensure the supported transition of vulnerable individuals and communities. There is also a redistributive element or thread to the broader concern with the equitable sharing of costs and benefits. This redistributive element arises from an earlier focus on historical injustice in contributions to climate change within UNFCCC principles (Okereke and Coventry, 2016) and articulations of climate justice by academics and environmental non-government organisations (ENGOs) (Schüssler, 2011; Klinsky and Dowlatabadi, 2011; Meyer and Roser, 2010; Roberts and Parks, 2009).

The second key concern that informs the just transition literature is related to the democratisation of decision making and life. This democratisation call is evident in several themes in the just transitions literature including the reform of current democratic institutions and practice (Routledge et al., 2018; Fischer, 2017), energy democracy (Hess, 2018; Szulecki, 2018; Burke and Stephens, 2017; Becker and Naumann, 2017), the localisation of decision making and control of resources (Fuller, 2017; Hodson and Marvin, 2010) and the re-making of current political structures, processes and institutions (Felli, 2019; Schlosberg, 2019; Schlosberg and Cravin, 2019). Overall, these themes indicate that political reform or transformation is key to scholars' formulations of a just transition.

Therefore, to evaluate whether an approach leads to a just transition, I argue there are some key questions to ask. Firstly, the obvious question is if the proposed approach actually leads to a reduction in fossil fuel dependence overall and carbon intensity.

Secondly, the approach should have the scope for equitable change at the local, national or global level. While local change is desireable, a lack of change at national and international levels will reduce the effectiveness of the approach. A focus only on local issues will lead to the possibility of simply displacing issues, rather than resolving them. Approaches capable of change only at the local level are likely to be questionable in overall effectiveness in bringing about transition. Thus, for a strong just transition, attention to broader impacts is needed.

Thirdly, approaches need to be evaluated based on whether they influence or locate responsibility at the individual, community, corporate or governmental level or across more than one of these dimensions. A focus on the individual and individual responsibility as the agent of change in a just transition approach removes the ability to trigger a timely movement towards political or social change. A reliance on cumulative individual actions to secure broader societal change relies on individual knowledge of what's required, on individuals having equitable ability to undertake required actions and the agency to do so. This highlights that strong approaches to a just transition go beyond the market logic of neoliberal environmentalism to challenge both individual responsibility and the further entrenching of elites via carbon markets. A strong just transition will include government regulation or intervention to ensure technological and other change. The success of such approaches in countries that have made rapid transitions to low carbon energy systems and to low carbon economies (Newbery, 2016; Geels et al., 2016) can already be observed. A focus on investors and the market as the driver of this innovation leads to outcomes based on profit only and misses the opportunity to secure just and sustainable outcomes.

Finally, approaches must be considered in terms of their ability to instigate change in the social, economic and political systems. Approaches with high capacity for a just transition will enable change in the status quo across all systems. In strong versions of a just transition, economic system(s) are reformed around sustainability, equity and redistributive justice. This would entail significant economic system change. Weak versions of just transition would see only minimal economic *system* change. Instead, economic tools or accommodations might be promoted including subsidies, tax breaks, side payments and other market based instruments to shift economic behaviour. Strong versions of just transition include the role and importance of political and social change, while weak versions do not. This change spans the spectrum from reforms to democracy to the formation of alternative social and political institutions (Schlosberg, 2019).

Therefore, I argue that just transition can be considered on a spectrum from weak to strong as outlined in Table 18.1 below.

Table 18.1 Criteria for evaluating just transitions

Weak just transition	Strong just transition
Fossil fuel dependence decreased	Fossil fuel dependence decreased
Leads to local change only	Leads to local, national and global change
Focus on individual responsibility as agent of change	Focus on communal and government responsibility as agent of change
Focus on market and investors to drive technological change	Focus on governments to invest in and foster technological and other change
Minimal economic system change	Leads to increased sustainability, equity and redistributive justice
	Political, social and economic change initiated

4 Current Transition Approaches

At this moment in time, a multitude of potential transition paths open before societies. These different paths are also differently available, depending on the society, its resources, its place in the global economy, its fossil fuel dependence. However, the paths are also differently available to groups and individuals within society.

This chapter focusses on two approaches within the transition debate—the green technology approach and the transition network movement. Each of these applies a quite different lens to the transition away from fossil fuels, highlighting different levels of change, different responsible agents and different drivers. To explore in depth two current examples of approaches to transition, I will use the criteria related to the just transition outlined above, to analyse whether the transition approaches meet the threshold for a just transition.

However, as I argue below, each approach fails to meet the benchmark for a just transition, though for different reasons. Critically, each approach fails to engage broader questions of social or political change. In each case, economic change is the focus, but in terms of change in material flows, rather than underlying structural or system change. While material flows can over time shift economic activity and investment, this political consumer approach (Ferrer-Fons and Fraile, 2013; Koos, 2012) is a relatively blunt instrument for the large scale change sought to drive a *just* transition. Schlosberg (2019: 18) reinforces this point in a recent paper, highlighting that "*social and political change happens within an ecosystem that links individual behaviour with material, institutional, and community processes and flows*". In addition, both analysed approaches embrace an individual or limited local mechanism for change, predicated on individuals' ability to pay, thus entrenching current inequity within the transition beyond fossil fuels. Below, this analysis is elaborated in further detail.

4.1 Green Technology

While the technology approach to transition is encompassed within a broader movement towards a "new economy", it is but one element of this movement. The movement includes a range of approaches with varying degrees of implied or explicit system change from sustainable materialism movements opting out of the global consumer culture (see Schlosberg and Coles, 2016), to consumer cooperative movements (Benander et al., 2017; Lengnick et al., 2015) to the move for circular production systems (McDonough and Braungart, 2008) and degrowth or steady state economies (North, 2017; Petridis et al., 2015).

Current thinking about how transition may occur has focussed on economic organisation and processes predominantly. This is firstly due to the dominance of market based solutions and marketisation in climate policy discussions and deliberations that drive the end of fossil fuels. For example, the UNFCCC and the Paris Agreement, as well as national debates including in the US, Australia, China, Canada and the UK, have all driven market based approaches to the end of fossil fuels, focussed on carbon commodification, but more significant is the creation of a global carbon economy (Boyd et al., 2011). These approaches, chosen by policy makers due to the least cost assumptions (Newell and Stavins, 2003; Whitten et al., 2003) and due to their fit with business-as-usual neoliberalism (Lohmann, 2011; Andrew et al., 2010; Bailey and Maresh, 2009) are removed from, and silent on, the question of transition, let alone *just* transition.

The advantage of such an approach for policymakers and for economic actors, is that it is silent on how transition should take place, when, and what should guide transition. This fits with the global obsession with small government in the mature liberal democracies (for example on the UK see: Smith and Jones, 2015) and a desire for governments to "*steer, not row*" (Deutsch, 1963). Transition at the whim of the market and market forces fails to consider who will bear the costs of transition and who will be able to co-opt the benefits. The state is able to reject its role in transition and justice in favour of the market and its efficiency. For the liberal democratic state this is convenient—it allows the avoidance of the intense polarisation of citizen beliefs about climate change action (McCright and Dunlap, 2011) and the confrontation of the deeply entrenched economic relationship between the state and fossil fuel interests (Pearse, 2009).

Of course, a significant literature reminds us that the market is not neutral, already engendering significant inequalities and inequities and garnering benefits for economic elites globally (Piketty, 2014; Coburn, 2000). This is already emerging in the carbon transition space. Given the profit motive, the solutions emerging in the market are those that drive benefits to elite economic actors leading investment in green technology, without questioning of pre-existing social, political or economic structures. The market and its logic are unable to provide any other solutions for a post-carbon world. Thus, the market is dominated by often expensive, high-tech solutions, geared to wealthy developed-world elites, entrenching inequality and inequity. These solutions are out of reach of those already disadvantaged within national and global economies. Thus, such an approach not only serves to keep intact, but further entrench global injustice, due to the inability to confront or incorporate transitional justice.

Thus, on the criteria for a strong just transition, the green technology approach can be evaluated, as shown in Table 18.2.

While there is potential in transition away from fossil fuels, it has limited potential for justice or systemic change.

4.2 Transition Network

The transition network, variously also referred to as transition towns or transition town movement, refers to local place based communal movements that seek to reduce fossil fuel dependence and improve sustainability at the town level. Individuals work together, often with local government, to increase resilience and social capital and to facilitate behavioural change and reduce carbon intensity (Bulkeley and Kern, 2006; Bulkeley, 2005). The network can be viewed as a transnational grassroots movement, with a significant concentration in Europe.

Table 18.2 Transitional justice in green technology transition approaches

Criteria for a strong just transition	Performance against the criteria
Fossil fuel dependence reduction	High potential
Leads to local change	High potential
Leads to national change	Mixed potential
Leads to global change	Limited
Leads to greater sustainability	Limited
Leads to greater redistributive justice	Not evident
Leads to greater equity	Not evident
Individual responsibility change	High potential
Community responsibility change	Limited
Corporate responsibility change	Limited
Government responsibility change	Not evident
Social system change	Not evident
Economic system change	Limited
Political system change	Not evident

The strength of the transition network and related movements includes the commons movement and the shareable economy, and their capture of local idealism and energy to transform local economies and communities (Barnes, 2015). Transition towns offer local places and spaces for grassroots innovation and this is their key strength. The transition towns provide a connection to place that anchors them in the local and the tangible for participants (see Devine-Wright, 2013; Coenen et al., 2012; Truffer and Coenen, 2012; Hodson and Marvin, 2010), something often missing in proposed climate change solutions. These spaces of experimentation, while they change the status quo (Ornetzeder and Rohracher, 2013; Seyfang and Haxeltine, 2012) are, I argue, also limited in terms of *just* transition potential.

The move to transition towns or transition network approaches, unlike the high-tech-environmental modernisation-green technology approach, is not an emphasis on personal responsibility to re-direct financial and material flows, but instead one that explicitly questions the state's ability to tackle the fossil-fuel transition.

In the vein of eco-anarchist experiments and eco-communities before them, transition towns, either implicitly or explicitly are 'giving up' on the state's willingness or ability to drive the social, economic or political change required to effectively bring about the end of the fossil fuel era. Such approaches are influenced by earlier theorists and 'small is beautiful' (Bookchin, 1982; Schumacher, 1973) in rejecting the state in favour of community living and organisation to a greater or lesser extent.

However, in terms of wide scale transition and transformation, such experiments fail, due to the issues of scale and coordination. This was a key issue identified with earlier such experiments (Dryzek, 1997). Firstly, transition towns and the impact of their changed social, economic and political processes, while representing a change experiment to demonstrate to others, provides only limited change in relation to national or global systems. Secondly, transition towns, and participation within them is limited. Transition towns are present in wealthier communities (Aiken, 2012), they lack diversity (Grossmann and Creamer, 2016) and there are significant social and economic barriers to entry (Ferguson and Lovell, 2015). These barriers to entry ensure that these utopian experiments are limited in their ability to confront or incorporate questions of equity or redistributive justice. This is also evident in the focus on individual responsibility for change practices and emphasis on sustainable materialism, within a limited local community framework. While changed material flows have an impact in terms of transition, larger structural and regulatory change is needed for targeted and urgent just transition. Thus, while transition towns can drive significant individual and local change, their

Table 18.3 Just transition evaluation of transition network approaches

Criteria for a strong just transition	Performance against the criteria
Fossil fuel dependence reduction	Local potential
Leads to local change	High potential
Leads to national change	Limited
Leads to global change	Limited
Leads to greater sustainability	High local potential
Leads to greater redistributive justice	Not evident
Leads to greater equity	Not evident
Individual responsibility change	High potential
Community responsibility change	High potential
Corporate responsibility change	Not evident
Government responsibility change	Not evident
Social system change	Limited
Economic system change	Limited
Political system change	Not evident

ability to re-configure national or global change is limited by the isolated and apolitical (Kenis and Mathijs, 2014) withdrawal from the state position taken. The strong focus on localisation and the idealising of the rural, additionally, render it incapable of attention to transnational and global concerns. In the local community context however, the emphasis on sustainable materialism can secure strong local benefits.

Thus, on the criteria for a strong just transition, transition networks can be evaluated as shown in Table 18.3 below.

Thus, transition network approaches provide high potential for local transitions, but not systemic change. However, the barriers to entry create significant questions for the potential for justice.

5 Where to Now?

The analysis above indicates that these two approaches away from fossil fuels fail the test for a just transition, despite having potential in a number of areas. Localisation approaches, reclaim some individual and communal agency in the face of climate change and global markets. Associated political consumer and green materialist approaches suffer from barrier to entry based on socio-economic circumstances and questionable scalability. These approaches serve as experiments and to move some material flows within the global economy, but don't drive a meaningful global transition alone. The green technology and ecological modernisation approach championed in Western Europe, serves only to entrench current structures and outcomes of inequality in the global economy. A neoliberal environmentalism approach, situated in the global economy and driven only by market forces, may provide progress towards transition, but not justly.

Just transition is important for normative and pragmatic reasons. Pragmatically, a transition that entrenches disadvantages and disproportionately places the burdens of transition on those that can least afford it and marginalises those that do not participate in the global economy, will do more than entrench inequality. Such an approach, based on individual agency or localisation approaches, with the market as driver, will actually widen inequality. There is a key link between widening inequality, social license for transition and political will on the part of politicians to address climate change. If political support and trust is unavailable, moves to transition in many polities and economies will be significantly undermined. The rise of right-wing populists, has been enabled by political disaffection with the inequality brought by integration in the global economy in the 1990s. The right-wing populist movement is additionally anti-environmental at its core due to ideological and cultural motivations arising from authoritarian and nationalistic values, combined with a significant anti-elite (including anti-science) sentiment (Lockwood, 2018). On top of this, right-wing populists often use the trope of the male mining worker to demonstrate what is wrong with both progressive politics and environmentalism. For example, we can see this in Trump's repeated public scepticism of climate change and dismantling of US environmental regulation (Hejny, 2018). Similarly the role of economic anxiety in post-industrial UK towns, leading to 'coal nationalism', exclusionary Englishness and anti-EU, anti-environmentalism pre-Brexist (Thorleifsson, 2016).

This demonstrates the complex political, social and economic implications of not ensuring a just transition. A transition that fails to reduce inequality will face much greater resistance, a more difficult and lengthy transition, with uneven social and political support nationally and internationally. This is without exploring the normative arguments around current and historic inequality in the contributions to, burdens arising from, cost and responsibility for climate change mitigation and adaptation present and well argued in the current literature (Schlosberg and Collins, 2014; Schlosberg, 2012; Okereke, 2010; Star, 2005).

So, what this tells us is that transition approaches without a focus on justice, including localisation, political consumerism and green technology, without moving beyond individual responsibility and agency, with the market as a driver, will fall prey to declining or partisan political will and fail to achieve transition goals in a timely way.

However, such approaches show potential or promise, when combined with additional levers of change, and with an added emphasis on communal, governmental and corporate responsibility, combined with government action. Citizens are much more supportive of transformational change when their communities are supported through change, rather than shouldering the burden of that change themselves. Current broad support for calls in the US for a Green New Deal demonstrate this. The Green New Deal proposal is premised on an economically and socially just transition and total economic transformation to respond to climate change (Tattersall, 2019). The nature of the proposal aims to fix climate change, re-enfranchise those impacted by globalisation and improve social and economic injustice.

This demonstrates that the need for a just transition provides multiple opportunities. To use the end of the fossil fuel transition to remake the global economy to be more just is one opportunity. The second opportunity is the chance to re-make the global economy in a way that decouples assumptions about the environment and development dichotomy, embracing instead alternative economic visions and discourses. This opportunity presented itself during the global financial crisis, and despite urging (Tienhaara, 2010), it was missed. Strong versions of just transition also re-open a space for dialogue and shared vision between the diverse interests of the 1990s anti-globalisation movement and the 2000s climate justice movement. This space, between environmental issues and economic flourishing, is one long foreclosed by marketised approaches to environmental improvements and by the state, driving an assumed and internalised trade-off between environment and development (Feiock and Stream, 2001). The option opens space for new pathways outside the environment-economy dichotomy entrenched within the modern state. The breaking of this dichotomy in strong just transitions, means the possibility of solutions to enhance both climate change mitigation and economic malaise. This presents imagined futures outside weak ecological modernisation approaches (Christoff, 1996) transforming Western Europe, coupled with neoliberal environmentalism.

Therefore, current movements and debates around transition are of great interest because they open new alliances. The development of these alliances is evident in campaigns to re-invent former mining communities, to prevent new coal developments in rural agricultural communities, to bring urban farming to poor communities, to empower local communities environmentally and economically, to build movements for green collar jobs and a green new deal. All of these movements build an explicit argument for environment *and* economy, engaging traditional political rivals in new alliances, with a vision of a more just future with a better economy and better environment for communities currently disenfranchised from, and by, neoliberal marketised environmentalism.

The third opportunity is the chance to re-awaken citizen engagement and political agency. While localisation and political consumerism alone cannot make the changes needed, they can form part of a broader plan for transition and ensure acceptance and social license from communities. Thus, a just transition provides a pathway to new future visions and paths, rather than remaining embedded in current unsustainable, inequitable ones.

6 Conclusion

This chapter has highlighted key challenges to be confronted in the move towards the end of the fossil fuel era. The transition from fossil fuels, as with any major economic transformation, brings with it alternative social, economic and political pathways towards change and different futures. As with major transformations, there are winners and losers within the transition away from fossil fuels. Thus, there are equity and justice implications within the low-carbon transition. The chapter has outlined both normative and pragmatic reasons why facilitating a *just* transition to a low carbon future is critical.

Two key alternative approaches to transition were critically analysed in light of criteria developed to examine compatibility with a just transition. For different reasons, each approach was determined to be limited. The green technology approach, emerging from the Western European ecological modernisation discourse, and entirely compatible with the Paris Agreement's global neoliberal environmentalism, is found to be particularly limited. While it demonstrates high potential for a low carbon future, it's potential to do so justly, rather than entrenching existing global elites and shifting burden and responsibility to individuals, is limited. Transition networks also come in for significant critique. While transition towns demonstrate good local potential for fossil fuel reduction and increased sustainability, their barriers to entry and lack of diversity, stunt their possibilities for social and economic change. In addition, their stated commitment to an apolitical stance reduces any opportunity to contribute to wider political change.

The implications of this are significant. Both approaches to transition—market driven and localisation—fail to address, and in fact further entrench, injustice beyond the end of fossil fuels. Far from recognising the transformation as a moment to restore equity, each approach entrenches current advantages to different groups of elites. The localisation approach can be thought of as a new move to enclosure on the part of local social and economic elites in transition towns, securing their place via barriers to entry. For green technology proponents, the transition opens new opportunities and pathways after capital's flight from fossil fuels. The dominance of neoliberal environmentalism in the global discourse enables further entrenchment of the power and economic advantaging of global economic elites. Both of these outcomes, without modifications, would entrench global injustice.

References

Aghion, P., Hepburn, C., Teytelboym, A. and Zenghelis, D. 2014. *Path Dependence, Innovation and the Economics of Climate Change*. Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment.

Aiken, G. 2012. Community Transitions to Low Carbon Futures in the Transition Towns Network (TTN). *Geography Compass* 6(2): 89–99.

Altvater, E. 2007. The Social and Natural Environment of Fossil Capitalism. *Socialist Register* 43: 37–59.

Andrew, J., Kaidonis, M.A. and Andrew, B. 2010. Carbon Tax: Challenging Neoliberal Solutions to Climate Change. *Critical Perspectives on Accounting* 21(7): 611–618.

Bailey, I. and Maresh, S. 2009. Scales and Networks of Neoliberal Climate Governance: The Regulatory and Territorial Logics of European Union Emissions Trading. *Transactions of the Institute of British Geographers* 34(4): 445–461.

Barnes, P. 2015. The Political Economy of Localization in the Transition Movement. *Community Development Journal* 50(2): 312–326.

Barr, S., and Pollard, J. 2017. Geographies of Transition: Narrating Environmental Activism in an Age of Climate Change and 'Peak Oil'. *Environment and Planning A: Economy and Space* 49(1): 47–64.

Beck, M., Rivers, N., Wigle, R., and Yonezawa, H. 2015. Carbon Tax and Revenue Recycling: Impacts on Households in British Columbia. *Resource and Energy Economics* 41: 40–69.

Becker, S. and Naumann, M. 2017. Energy Democracy: Mapping the Debate on Energy Alternatives. *Geography Compass* 11(8): 1–13.

Benander, L., Horowitz, D.A. and Baker, I. 2017. New Economy Energy Cooperatives Bring Power to the People. In: Fairchild, D. and Weinrub, A. (Eds.) *Energy Democracy*. Washington, DC: Island Press.

Binder, T., Brandt, E., Ehn, P. and Halse, J. 2015. Democratic Design Experiments: Between Parliament and Laboratory. *CoDesign* 11(3–4): 152–165.

Bleiker, R. 2002. Activism after Seattle: Dilemmas of the Anti-globalisation Movement. *Pacifica Review: Peace, Security and Global Change* 14(3): 191–207.

Bookchin, M. 1982. *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy.* Palo Alto, CA: Cheshire Books.
Bouzarovski, S., Herrero, S. T., Petrova, S. and Ürge-Vorsatz, D. 2016. Unpacking the Spaces and Politics of Energy Poverty: Path-Dependencies, Deprivation and Fuel Switching in Post-communist Hungary. *Local Environment* 21(9): 1151–1170.
Boyd, E., Boykoff, M. and Newell, P. 2011. The 'New' Carbon Economy: What's New?. *Antipode* 43(3): 601–611.
Braun, K. and Könninger, S. 2018. From Experiments to Ecosystems? Reviewing Public Participation, Scientific Governance and the Systemic Turn. *Public Understanding of Science* 27(6): 674–689.
Breetz, H., Mildenberger, M. and Stokes, L. 2018. The Political Logics of Clean Energy Transitions. *Business and Politics* 20(4): 492–522.
Brett, J. 2003. *Australian Liberals and the Moral Middle Class: From Alfred Deakin to John Howard*. Cambridge: Cambridge University Press.
Brett, J. 2005. Relaxed and Comfortable: The Liberal Party's Australia. *Quarterly Essay*, Issue 19.
Bulkeley, H. 2005. Reconfiguring Environmental Governance: Towards a Politics of Scales and Networks. *Political Geography* 24(8): 875–902.
Bulkeley, H. and Kern, K. 2006. Local Government and the Governing of Climate Change in Germany and the UK. *Urban Studies* 43(12): 2237–2259.
Burke, M.J. and Stephens, J.C. 2017. Energy Democracy: Goals and Policy Instruments for Sociotechnical Transitions. *Energy Research and Social Science* 33: 35–48.
Chilvers, J. and Pallett, H. 2018. Energy Democracies and Publics in the Making: A Relational Agenda for Research and Practice. *Frontiers in Communication* 3. https://doi.org/10.3389/fcomm.2018.00014.
Christoff, P. 1996. Ecological Modernisation, Ecological Modernities. *Environmental Politics* 5(3): 476–500.
Ciplet, D. and Roberts, J.T. 2017. Climate Change and the Transition to Neoliberal Environmental Governance. *Global Environmental Change* 46: 148–156.
Coburn, D. 2000. Income Inequality, Social Cohesion and the Health Status of Populations: the Role of Neo-Liberalism. *Social Science and Medicine* 51(1): 135–146.
Coenen, L., Benneworth, P. and Truffer, B. 2012. Toward a Spatial Perspective on Sustainability Transitions. *Research Policy* 41(6): 968–979.
Della Bosca, H. and Gillespie, J. 2018. The Coal Story: Generational Coal Mining Communities and Strategies of Energy Transition in Australia. *Energy Policy* 120: 734–740.
Deutsch, K.W. 1963. *The Nerves of Government: Models of Political Communication*. New York: Free Press.
Devine-Wright, P. 2013. Think Global, Act Local? The Relevance of Place Attachments and Place Identities in a Climate Changed World. *Global Environmental Change* 23(1): 61–69.

Dryzek, J.S. 1997. *The Politics of the Earth: Environmental Discourses*. New York: Oxford University Press.

Feiock, R.C. and Stream, C. 2001. Environmental Protection Versus Economic Development: A False Trade-Off?. *Public Administration Review* 61(3): 313–321.

Felli, R. 2019. Beyond the Critique of Carbon Markets: The Real Utopia of a Democratic Climate Protection Agency. *Geoforum* 98: 236–243.

Ferguson, R.S. and Lovell, S.T. (2015). Grassroots Engagement with Transition to Sustainability: Diversity and Modes of Participation in the International Permaculture Movement. *Ecology and Society* 20(4). http://www.jstor.org/stable/26270300.

Ferrer-Fons, M. and Fraile, M. 2013. Political Consumerism and the Decline of Class Politics in Western Europe. *International Journal of Comparative Sociology* 54(5–6): 467–489.

Fischer, F. 2017. *Climate Crisis and the Democratic Prospect: Participatory Governance in Sustainable Communities*. Oxford: Oxford University Press.

Fotopoulos, T. 2001. Globalisation, the Reformist Left and the Anti-globalisation 'Movement'. *Democracy and Nature* 7(2): 233–280.

Freeden, M. 2017. After the Brexit Referendum: Revisiting Populism as an Ideology. *Journal of Political Ideologies* 22(1): 1–11.

Fuller, S. 2017. Embedding Energy Transitions in the Community. In: Bouzarovski, S., Pasqualetti, M.J. and Broto, V.C. (Eds.) *The Routledge research companion to energy geographies*. New York: Routledge, pp. 265–276.

Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M. and Wassermann, S. 2016. The Enactment of Socio-Technical Transition Pathways: A Reformulated Typology and a Comparative Multi-level Analysis of the German and UK Low-Carbon Electricity Transitions (1990–2014). *Research Policy* 45(4): 896–913.

Grossmann, M. and Creamer, E. 2016. Assessing Diversity and Inclusivity Within the Transition Movement: An Urban Case Study. *Environmental Politics* 26(1): 161–182.

Hall, N. and Star, C. 2007. Are They Hitting the Target? Climate Change Messages and Strategies by Australian NGOs. In: Ensor, J., Polak, I. and ven de Merwe, P. (Eds.) *Other Contact Zones.* Perth: Network Books, pp. 137–147.

Healy, N. and Barry, J. 2017. Politicizing Energy Justice and Energy System Transitions: Fossil Fuel Divestment and a "Just Transition". *Energy Policy* 108: 451–459.

Hejny, J. 2018. The Trump Administration and Environmental Policy: Reagan Redux?. *Journal of Environmental Studies and Sciences* 8(2): 197–211.

Hess, D.J. 2018. Energy Democracy and Social Movements: A Multi-coalition Perspective on the Politics of Sustainability Transitions. *Energy Research and Social Science* 40: 177–189.

Hobolt, S.B. 2016. The Brexit Vote: A Divided Nation, a Divided Continent. *Journal of European Public Policy* 23(9): 1259–1277.

Hodson, M. and Marvin, S. 2010. Can Cities Shape Socio-Technical Transitions and How Would We Know If They Were?. *Research Policy* 39(4): 477–485.

Holmes, D. and Star, C. 2018. Climate Change Communication in Australia: The Politics, Mainstream Media and Fossil Fuel Industry Nexus. In: Leal Filho, W., Manolas, E., Azul, A.M., Azeiteiro, U.M. and McGhie, H. (Eds.) *Handbook of Climate Change Communication: Vol. 1: Theory of Climate Change Communication*. Cham: Springer, pp. 151–170.

Hultgren, J. 2018. Those Who Bring from the Earth: Anti-environmentalism and the Trope of the White Male Worker. *Ethics, Policy and Environment* 21(1): 21–25.

Ikeme, J. 2003. Equity, Environmental Justice and Sustainability: Incomplete Approaches in Climate Change Politics. *Global Environmental Change* 13(3): 195–206.

Janković, V. and Bowman, A. 2014. After the Green Gold Rush: The Construction of Climate Change as a Market Transition. *Economy and Society* 43(2): 233–259.

Johnstone, P. and Hielscher, S. 2017. Phasing Out Coal, Sustaining Coal Communities? Living with Technological Decline in Sustainability Pathways. *The Extractive Industries and Society* 4(3): 457–461.

Kenis, A. and Mathijs, E. 2014. (De)politicising the Local: The Case of the Transition Towns Movement in Flanders (Belgium). *Journal of Rural Studies* 34: 172–183.

Klinsky, S. and Dowlatabadi, H. 2011. Conceptualizations of justice in Climate policy. *Climate Policy* 9(1): 88–108.

Koos, S. 2012. What Drives Political Consumption in Europe? A Multi-level Analysis on Individual Characteristics, Opportunity Structures and Globalization. *Acta Sociologica* 55(1): 37–57.

Laurent, B. 2016. Political Experiments That Matter: Ordering Democracy from Experimental Sites. *Social Studies of Science* 46(5): 773–794.

Lengnick, L., Miller, M. and Marten, G.G. 2015. Metropolitan Foodsheds: A Resilient Response to the Climate Change Challenge?. *Journal of Environmental Studies and Sciences* 5(4): 573–592.

Lobao, L., Zhou, M., Partridge, M. and Betz, M. 2016. Poverty, Place, and Coal Employment Across Appalachia and the United States in a New Economic Era. *Rural Sociology* 81(3): 343–386.

Lockwood, M. 2018. Right-Wing Populism and the Climate Change Agenda: Exploring the Linkages. *Environmental Politics* 27(4): 712–732.

Lohmann, L. 2011. The Endless Algebra of Climate Markets. *Capitalism Nature Socialism* 22(4): 93–116.

May, P. 2015. Implementation Failures Revisited: Policy Regime Perspectives. *Public Policy and Administration* 30(3–4): 277–299.

McCright, A. and Dunlap, R. 2011. The Politicization of Climate Change and Polarization in the American Public's Views of Global Warming 2001–2010. *The Sociological Quarterly* 52(2): 155–194.

McDonough, W. and Braungart, M. 2008. Remaking the Way We Make Things: Creating a New Definition of Quality with Cradle-to-Cradle Design. In:

Marinova, D., Annandale, D. and Phillimore, J. (Eds.) *The International Handbook on Environmental Technology and Management*. Cheltenham: Edward Elgar, pp. 33–48.

McDougall, D. 2018. From Malcolm Turnbull to ScoMo: Crisis for the Centre-Right in Australia. *The Round Table* 107(5): 557–570.

Meng, S., Siriwardana, M. and McNeill, J. 2013. The Environmental and Economic Impact of the Carbon Tax in Australia. *Environmental and Resource Economics* 54(3): 313–332.

Meyer, L. H. and Roser, D. 2010. Climate Justice and Historical Emissions. *Critical Review of International Social and Political Philosophy* 13(1): 229–253.

Munck af Rosenschold, J. and Rozema, J.G. 2014. Institutional Inertia and Climate Change: A Review of the New Institutionalist Literature. *WIREs Climate Change* 5(5): 639–648.

Newbery, D.M. 2016. Towards a Green Energy Economy? The EU Energy Union's Transition to a Low-Carbon Zero Subsidy Electricity System—Lessons from the UK's Electricity Market Reform. *Applied Energy* 179: 1321–1330.

Newell, P. and Mulvaney, D. 2013. The Political Economy of the 'Just Transition'. *The Geographical Journal* 179(2): 132–140.

Newell, R.G. and Stavins, R.N. 2003. Cost Heterogeneity and the Potential Savings from Market-Based Policies. *Journal of Regulatory Economics* 23(1): 43–59.

North, P. 2017. Transitioning Towards Low Carbon Solidarity Economies? In: North, P. and Cato, M.S. (Eds.) *Towards Just and Sustainable Economies: The Social and Solidarity Economy: The Social Solidarity Economy North and South*. Bristol: Policy Press, pp. 73–96.

Okereke, C. 2010. Climate Justice and the International Regime. *WIREs Climate Change* 1(3): 462–474.

Okereke, C. and Coventry, P. 2016. Climate Justice and the International Regime: Before, During, and After Paris. *WIREs Climate Change* 7(6): 834–851.

Oreskes, N. and Conway, E. M. 2010. *Merchants of Doubt*. New York: Bloomsbury Press.

Ornetzeder, M. and Rohracher, H. 2013. Of Solar Collectors, Wind Power, and Car Sharing: Comparing and Understanding Successful Cases of Grassroots Innovations. *Global Environmental Change* 23(5): 856–867.

Pearse, G. 2009. Quarry Vision: Coal, Climate Change and the End of the Resources Boom. *Quarterly Essay* 33: 1–122.

Petridis, P., Muraca, B. and Kallis, G. 2015. Degrowth: Between a Scientific Concept and a Slogan for a Social Movement. In: Martinez-Alier, J. and Muradian R. (Eds.) *Handbook for Ecological Economics*. Cheltenham: Edward Elgar, pp. 176–200.

Piketty, T. 2014. *Capital in the Twenty-First Century*. New York: Belknap/Harvard University Press.

Quinn-Thibodeau, T. and Wu, B. 2016. NGOs and the Climate Justice Movement in the Age of Trumpism. *Development* 59: 251–256.

Roberts, J.T. and Parks, B.C. 2009. Ecologically Unequal Exchange, Ecological Debt, and Climate Justice: The History and Implications of Three Related Ideas for a New Social Movement. *International Journal of Comparative Sociology* 50(3–4): 385–409.

Rosemberg, A. 2010. Building a Just Transition: The Linkages Between Climate Change and Employment. *International Journal of Labour Research* 2(2): 125–161.

Routledge, P., Cumbers, A. and Derickson, K.D. 2018. States of Just Transition: Realising Climate Justice Through and Against the State. *Geoforum* 88: 78–86.

Schlosberg, D. 2012. Climate Justice and Capabilities: A Framework for Adaptation Policy. *Ethics and International Affairs* 26(4): 445–461.

Schlosberg, D. 2019. From Postmaterialism to Sustainable Materialism: The Environmental Politics of Practice-Based Movements. *Environmental Politics*. https://doi.org/10.1080/09644016.2019.1587215.

Schlosberg, D. and Coles, R. 2016. The New Environmentalism of Everyday Life: Sustainability, Material Flows and Movements. *Contemporary Political Theory* 15: 160–181.

Schlosberg, D. and Collins, L. 2014. From Environmental to Climate Justice: Climate Change and the Discourse of Environmental Justice. *WIREs Climate Change* 5(3): 359–374.

Schlosberg, D. and Cravin, L. 2019. *Sustainable Materialism: Environmental Movements and the Politics of Everyday Life*. Oxford: Oxford University Press.

Schumacher, E.F. 1973. *Small Is Beautiful: Economics as If People Mattered*. New York: Harper & Row Publishers.

Schüssler, R. 2011. Climate Justice: A Question of Historic Responsibility?. *Journal of Global Ethics* 7(3): 261–278.

Seyfang, G. and Haxeltine, A. 2012. Growing Grassroots Innovations: Exploring the Role of Community-Based Initiatives in Governing Sustainable Energy Transitions. *Environment and Planning C: Government and Policy* 30(3): 381–400. https://doi.org/10.1068/c10222.

Smith, M. and Jones, R. 2015. From Big Society to Small State: Conservatism and the Privatisation of Government. *British Politics* 10(2): 226–248.

Speer, J. 2012. Participatory Governance Reform: A Good Strategy for Increasing Government Responsiveness and Improving Public Services?. *World Development* 40(12): 2379–2398.

Star, C. 2005. Notions of Ecological Citizenship in Climate Justice Campaigns. *Ecopolitics XVI: Transforming Environmental Governance for the 21st Century*, July 4–6, Griffith University, Brisbane. ISBN 190295239X.

Star, C. 2012. A Tale of Two Movements? Environmental Non-government Organisations and Community Action on Climate Change. *Social Alternatives* 31(1): 10–15.

Stevis, D. and Felli, R. 2015. Global Labour Unions and Just Transition to a Green Economy. *International Environmental Agreements: Politics, Law and Economics* 15(1): 29–43.

Szulecki, K. 2018. Conceptualizing Energy Democracy. *Environmental Politics* 27(1): 21–41.

Tattersall, A. 2019. Alexandria Ocasio-Cortez Can Teach Bill Shorten a Thing or Two About Climate Change Policy. *The Guardian*, March 11. https://www.theguardian.com/commentisfree/2019/mar/11/alexandria-ocasio-cortez-can-teach-bill-shorten-a-thing-or-two-about-climate-change-policy.

Thorleifsson, C. 2016. From Coal to Ukip: The Struggle Over Identity in Post-industrial Doncaster. *History and Anthropology* 27(5): 555–568.

Tienhaara, K. 2010. A Tale of Two Crises: What the Global Financial Crisis Means for the Global Environmental Crisis. *Environmental Policy and Governance* 20(3): 197–208.

Truffer, B. and Coenen, L. 2012. Environmental Innovation and Sustainability Transitions in Regional Studies. *Regional Studies* 46(1): 1–21.

Velicu, I. and Kaika, M. 2017. Undoing Environmental Justice: Re-imagining Equality in the Rosia Montana Anti-mining Movement. *Geoforum* 84: 305–315.

Vona, F. 2019. Job Losses and Political Acceptability of Climate Policies: Why the 'Job-Killing' Argument Is So Persistent and How to Overturn It. *Climate Policy* 19(4): 524–532.

Wagner, L., Ross, I., Foster, J. and Hankamer, B. 2016. Trading Off Global Fuel Supply, CO_2 Emissions and Sustainable Development. *PLoS ONE* 11(3): 1–17.

Whitten, S., van Bueren, M. and Collins, D. 2003. An Overview of Market-Based Instruments and Environmental Policy in Australia. In: *Proceedings of the Sixth Annual AARES National Symposium, Rural Industries Research and Development Corporation*. Canberra, pp. 6–23.

19

Is Energy Justice in the Fossil Fuel Industry a Paradox?

Tedd Moya Mose and Mohammad Hazrati

1 Introduction

The UN (United Nations) Global Goals on affordable and Clean Energy enjoin us to change the production and consumption of energy from the current reliance on fossil fuels to more sustainable and less harmful ways (Global Goals, 2019). In theory, these principles appear laudable but face very complex practical difficulties. The first puzzle of this transition is in its aim; to divest from fossil fuels which dominate the global energy mix. This proposed divestiture from carbon intensive energy is seen as a key pillar for developing a sustainable "*global energy system*" (Intergovernmental Panel on Climate Change (IPCC), 2014: 1261).[1] 'Fossil fuels' here refers to those that are depletable and finite (Wood, 2018), and release carbon dioxide (CO_2) emissions (including coal, oil and gas) to the atmosphere whereas 'sustainable energysystem operator' resources are produced and used in ways that support human development over the long term in all of its social, economic, and environmental dimensions (Ottinger et al., 2005). The definition of the 'fossil

[1] The energy system comprises all of the components related to the production, conversion, delivery and use of energy.

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fuel industry' in this paper is generous. It includes all participants in the exploitation and management of fossil fuels and their infrastructure from: extraction, processing, transportation, conversion into different energy forms, trade, consumption, waste disposal and decommissioning. For the avoidance of doubt, it involves both public or state entities and (especially) private parties.

Presently, there is substantial global reliance on fossil fuels to meet the rising energy demand; even though they increase global greenhouse gas (GHG) emissions (International Energy Agency (IEA), 2018c).[2] As recently as September 2018, global oil sale statistics were record-shattering, exceeding the 100 million barrels a day mark (IEA, 2018b).[3] So, on one the hand, there is an urgent global appetite for fossil fuels while on the other there are international campaigns against fossil fuel use. Conversely, global energy poverty is rife. More than 1 billion people lack access to modern energy services (viz electricity) (IEA, 2015). More than 2.7 billion people are also reliant on traditional solid biomass for cooking, heating or lighting in poorly ventilated spaces (IEA, 2017). The consequences of lack of access are devastating. The combustion of rudimentary biomass leads to the premature deaths of more than 4 million people each year with many others suffering serious health problems (World Health Organization (WHO), 2016). The most vulnerable are women and children living in severe poverty (WHO, 2016). Even in developed markets such as the United Kingdom (UK), the European Union (EU), and the United States (US), a significant number of people have poor energy supply or simply cannot afford to pay the increased energy costs in colder months. This increases the morbidity and mortality rates of vulnerable members in these societies (UK Office for National Statistics, 2015). It is no wonder, therefore, that most black carbon emissions[4] (US Environmental Protection Agency (EPA), 2016) in developed countries are associated with biomass and fossil fuel combustion for heating (EPA, 2012).[5]

'Energy justice' concerns itself with identifying when and where injustices occur in energy systems and how best law and policy can respond (Heffron et al., 2015). Energy and justice may appear oxymoronic given the commer-

[2] Fossil fuels contribute two-thirds of global GHG emissions leading to global warming (IEA, 2018c).

[3] The Oil Market Report September 2018 (IEA, 2018b) highlighted, "*Global supply in August reached a record 100 mb/d as higher output from OPEC offset seasonal declines from non-OPEC*." See also CNBC Markets (2018).

[4] The US EPA (2016: 205) report defines Black Carbon as "*the most strongly light-absorbing component of particulate matter* (*PM*)*, and is formed by the incomplete combustion of fossil fuels, biofuels, and biomass*."

[5] The US EPA (2016: 210) report also mentions that, "*Household energy use represents an extremely important source of black carbon emissions worldwide, accounting for 25% of the total global BC inventory*."

cial stakes involved in the global energy industry. However, contemporary energy challenges necessitate the inclusion of justice and fairness in the energy value chains for all fuels (Sovacool and Dworkin, 2015).[6] Fundamentally, justice is a double-edged sword because the same principles of fairness ought to be equitably applied to all stakeholders (Sovacool and Dworkin, 2014: 15). The idea, therefore, that the main aim of the transition to sustainable energy is to exclude fossil fuels from the energy mix appears antithetical. Assuming that this transition itself were the main object of energy justice case (as some argue) (Robins et al., 2018), then exclusion of the fossil fuel industry from the decision-making process in the transition would be unjustifiable. It would be incongruous with fairness and (procedural) justice. Thus, it is essential for energy justice to be inclusive and attempt to harmonise the nebulous approaches to the energy transition. Should a harmonised strategy by all energy stakeholders be too onerous to immediately implement, it might be necessary to take an urgent collaborative approach in the just transition (between the fossil fuel industry and the sustainable energysystem operator advocates). This chapter further calls for cooperation between nation states in the management of energy resources because the real value is in international cooperation and not just mere peaceful co-existence between countries (Weil, 1983). Simply put, this work suggests that energy justice is an imperative. Its principles would—indeed should be—beneficially applied to all resources and their value chains in the energy sector.

If we believe that justice is the first virtue of social institutions, then no matter how efficient an unjust system is working, it must be reformed (Rawls, 1999: 3). There some inherent injustices in fossil fuels. The three major intrinsic negative qualities are: (a) carbon-intensity, (b) fossil fuels are depletable and non-renewable, and (c) they are unevenly distributed around the world. This last characteristic leads to geographic disparity in the production and consumption of fossil fuels. It is also necessary to consider other less-obvious injustices that may be latent in or associated with fossil fuels and their fuel cycles. One justification for this approach is that, in energy justice discourse, social inclusion is as important as environmental protection and economic efficiency. At the international level, this is the realm of the 'energy trilemma', formulated by the World Energy Council (WEC, 2015), and discussed in

[6] Sovacool and Dworkin (2015: 435) state that, "*Our species is drifting into a future threatened with climate change and rising sea levels, burgeoning levels of energy-related pollution which threaten our health, aggravated scarcity and insecurity of energy fuels, the proliferation of nuclear weapons, and a host of other hazards. This creates pressing ethical conundrums with no easy resolution. It is becoming increasingly clear that routine energy analyses do not offer suitable answers to these sorts of issues*." See also Sect. 4 that uses the energy trilemma as a prism that frames the current global energy challenges.

Sect. 4 below as a prism for holistic balancing of common global energy challenges.

Following this introduction, this chapter is set out as follows: Sect. 2 looks at the negative impacts of fossil fuels and how energy justice principles may functionally attempt to address these impacts. Section 3 highlights the benefits of modern energy services that fossil fuels may bring and suggests that energy justice should not be excluded from the fossil fuel industry—but rather—be more involved in creating a sustainable energysystem operator future. Section 4 underscores the importance of the law and energy justice in resolving the energy trilemma. Energy occupies a fundamental place in daily life. While the absence of modern energy services prevents the energy poor from enjoying unspoiled nature, a world with modern energy supply that spoils nature makes life unenjoyable. This chapter argues that it is not only practical to include the energy justice framework in the fossil fuel industry but also that the success of a low-carbon future may be hinged on it.

2 Is the Fossil Fuel Industry on Trial? The Tenets of Energy Justice and Fossil Fuels

We are in a carbon-fuelled global economy. "Modern renewables" (primarily wind, solar and biofuels) are projected to be the fastest growing energy source by 2035, but even then renewables will still not exceed single-digit percentage points in the energy mix (McCauley, 2018: 2). In 2016, at least seven unprecedented climate conditions occurred: consecutive hottest months; hottest day in India in recorded history; hottest autumn ever recorded in Australia and highest amount of destruction in Australia's Great Barrier Reef; highest temperature in Alaska; the maximum extent melting of Arctic ice ever recorded; and the highest annual increase in global CO_2 emissions (Vaughan, 2016). Early reports in 2018 prove that these records are progressively getting broken (Watts, 2018). There is an increasing concentration of CO_2, the most abundant GHG in the atmosphere, mainly because of the burning of fossil fuels (Quéré et al., 2018). The concentration of GHGs in the atmosphere is directly linked to the average global temperature on earth (UN, n.d.). Climate change is, therefore, a common global conundrum that has been described as "*the greatest energy-related externality of all time*" (Stern, 2006: 1).

Apart from climate change concerns, scarcity is another challenge for fossil fuels and has three dimensions: (1) as finite resources, fossil fuels are harder to extract as easily-accessible resources are depleting, (2) fossil fuels cause scarcity of other natural resources (coal mining and hydrocarbon production negatively impact water, air, arable land and forests),[7] (3) fossil fuels need such high financial input that they create a cycle of dependence especially for poorer regions.[8] These enhance inter-generational apprehensions of consuming non-renewable resources with abandon. The imperative of (fossil-fuelled) security of supply for a burgeoning human population forecasts a future energy demand that would be at odds with the aim of decarbonising future energy systems. Global distribution patterns of oil and gas reserves are naturally unequal. The fact that certain minerals abound in certain places and not in others is a natural phenomenon that comes with an innate unfairness in the natural distribution of fossil fuel resources around the world (Walker, 2009). This means that some countries disproportionately enjoy the benefits of being the main consumers and/or producers of these resources. Meanwhile, the non-localised global costs (mainly environmental impacts and climate change) of fossil fuel use are shouldered by all inhabitants of the world. Furthermore, in an increasingly globalised world, societies that are most dependent upon primary energy resources like oil obtain their energy from other states (Smart, 1981). In other words, there can be localised negative impacts of fossil fuel production with a corresponding benefit of energy consumption by populations that are detached from the negative consequences of production.

In terms of inherent injustice because of their non-renewable nature, fossil fuels are finite and (once used) are effectively gone because they take literally geologic ages (in millions of years) to re-form. Consumption of these resources by one generation leaving nothing but empty wells and costs, also results in intergenerational inequity. The unfairness being that the current generation enjoys the benefits of depletable fossil fuels while imposing the perils of climate change for future heirs of the planet. The other main negative environmental impacts from oil and gas activities are: oil leakage, spills, and flaring of excess gas.[9] Mining activities associated with fossil fuels can also lead to mine tailings and coal mine fires (Liebenthal et al., 2005). Table 19.1 shows the main potential environmental impacts of petroleum and mining activities.

[7] It is estimated that the amount of water consumption for the production of one Gigajoule (GJ) of conventional oil, conventional gas, coal, oil sands, and shale gas are 0.081 m^3, 0.004 m^3, 0.043 m^3, 0.114 m^3, and 0.017 m^3, respectively. See Spang et al. (2014).

[8] It is worth mentioning that 38% of the world's shale resources are in areas that either are arid or are experiencing extremely high levels of water stress; also, 386 million people live in these areas. See Reig et al. (2014).

[9] About 5% of the gas produced around the world is being flared or vented. In 2017, about 141 billion cubic meters (bcm) of natural gas was flared. It causes more than 350 million tons of CO_2 emissions every year, with serious harmful impacts from un-combusted methane and black carbon emissions. See The World Bank (2018).

Table 19.1 Petroleum and mining activities—key potential environmental impacts

Environmental issues	Key environmental impacts
Air quality	Flaring & venting of excess gas; Decommissioning of infrastructure; Use (& burning) of diesel to produce power for the mine; Emissions from associated machinery used; Fugitive gases from vehicles & construction phase; Pollution from diesel engines and gas turbines; Tailings treatment following infrastructure closure
Biodiversity & deforestation	Seismic surveys (& associated noise and impacts) affecting marine life (offshore); Drilling, blasting, construction of infrastructure (e.g. wells, pipelines, etc.); Oil spills; Use of toxic materials; Extraction near sensitive habitats (e.g. coastal reefs, wetlands, etc.)
Soils	Water and soil contamination; Land degradation due to deforestation and loss of soil; Loss of wildlife habitats, reduction in plant diversity; Soil erosion & contamination due to poor waste management
Water Resources	Sedimentation; Increased salinity and changes to water resulting in inability for human & animal consumption; Water contamination from waste discharges & leaks/pollution (including into groundwater)

Source: Adapted from the Extractives Hub (2017)

Energy Justice is suggested as one of the tools that can address these problems. Conceptualised as having three principal tenets (distributional justice, procedural justice and recognition justice) (Sovacool and Dworkin, 2014), energy justice deals with both macro-justice (on societal impacts of energy and how fair and just their institutional decisions are) as well as micro-justice (how individuals are impacted by systemic outcomes) (McCauley et al., 2013). Procedural equity advocates for the inclusion of all stakeholders in energy systems to participate in decision making (Heffron et al., 2015). Energy justice is manifest in global energy systems through two distinctive characteristics: one, they fairly propagate both the benefits and costs of energy services, and two, they are representative and impartial in energy decision-making. At a more local scale, it is suggested that energy justice has practical application to the functioning energy systems at a spatial or decentralised level (McCauley et al., 2016).[10]

This chapter sees the contribution of energy justice in both conceptual and normative terms that identify where energy injustices occur and proposes ways in which these injustices can be stopped, reduced or reversed (Jenkins

[10] McCauley et al. (2016: 14) suggest some practical applications of energy justice such as guiding policy and offering assistance in determining where to site energy infrastructure.

et al., 2016). Energy justice provides a framework that also helps to determine how best law and policy can respond to these injustices (Heffron et al., 2015). Here, we examine how energy justice principles can be applied to the fossil fuel industry even as long-term sustainable energysystem operator solutions are sought.

2.1 Distributional Justice and Fossil Fuels

Distributional justice[11] focuses on the distribution of energy as a social good and examines where costs of energy provision appear as a social ill. Hence, addressing injustices where they emerge in energy system processes (Sari et al., 2018). Distributional justice recognises both the physically unequal allocation of environmental benefits and ills, and the uneven distribution of their associated responsibilities. It advocates for a more non-discriminatory distribution of benefits and ills on all members of society. Distributional justice is not only concerned with the siting of infrastructure, but also with access to energy services too (Jenkins et al., 2016). So, distributional justice in the energy system can be explained from both a consumption perspective as well as a production one. From a consumption standpoint, it deals with the fuel poverty agenda, and from a production viewpoint, it focuses on costs and burdens associated with all activities through the up-stream, mid-stream and downstream chain. These activities include: exploration, extraction, production and decommissioning in the upstream, resource storage and transportation in the mid-stream and refining and distribution of products in the downstream (Devold, 2013).

From a production perspective, the potential negative impacts of fossil fuel projects can be broadly categorised into two main groups, namely: environmental and social impacts (including public health and safety as well as economic disruption). Notably, the impacts of mining and oil and gas operations are likely to increase as projects move through their life cycle, from exploration to closure. Mitigation of these impacts depends on the location, size, deployed technology and complexity of a project (UN Environmental Program (UNEP), 1997). For workers and individuals residing near the projects, these negative environmental threats can cause or exacerbate the risk of contracting serious health problems, chronic diseases or cancers (Scientific Committee on Health, Environmental and Emerging Risks, 2018). Also, occupational risks are high in the petroleum and mining activities because

[11] Used interchangeably with 'distributive justice' in this chapter.

their activities often, involve large, heavy equipment, significant construction-related projects and hazardous chemicals. Workers are at danger of exposure to chemicals, physical or biological agents, ergonomic, psychosocial and mental risks (UN Development Program (UNDP), 2017).

Health impacts can be wider than those directly associated with occupational risks. There are also indirect health effects caused by the introduction of fossil fuel projects that alter the physical and social environment (WHO, 2010). For example, starting a large project can lead to rapid population migration in search for employment, which in turn can cause serious negative ramifications for communities living in that area. These adverse consequences range from health impacts (such as carrying different disease that did not exist in that society or accelerating the transmission of infectious disease, vector-borne disease and sexually transmitted disease) to social impacts (like cultural conflicts between the new arrivals and local people) (WHO, 2010). Table 19.2 shows some of the most important potential public health and safety risks associated with petroleum and mining projects.

Negative social impacts might arise from land acquisition, changing demographics and involuntary resettling of local populations (including indigenous people). There is also a real possibility of disrupting traditional life-styles and heritages to make way for extractive industries, and project dependence leading to unemployment at end of life and abandoned energy infrastructures

Table 19.2 Petroleum and mining activities—public health and safety risks

Project issues	Health and safety risks
Land use change	Stress & mental health problems associated with loss of access to lands/livelihoods; Decreased food security and associated impacts on diet and nutrition; Health problems (e.g. diarrheal diseases) due to low quality/quantity of water
Population migration	Infectious diseases and foodborne diseases if services & infrastructure not developed sufficiently/quickly to meet rapidly increasing demands; Sexually transmitted diseases (e.g. HIV/AIDS), respiratory diseases (e.g. tuberculosis) and other diseases (e.g. measles, malaria and other vector-borne diseases, zoonotic and parasitic diseases) due to mixing different populations and over-crowding
Environmental pollution	Respiratory diseases (e.g. asthma, silicosis); Increased risk of cancers, skin allergies, opthalmological irritations, blindness; Mental health problems & stress arising from environmental disturbance; Neurological diseases arising from heavy metal exposure (e.g. lead, mercury); Congenital anomalies from in utero exposure to heavy metals and other chemicals; Cardiovascular effects; Deafness; Deaths, injuries and handicaps from trauma related accidents

Source: Adapted from World Health Organization (2010)

(Liebenthal et al., 2005). Numerous human rights violations associated with petroleum and mining activities include: loss of land and livelihoods without negotiation or compensation, violation of labour rights and force resettlement (Cameron and Stanley, 2017).

2.2 Recognition Justice

In the energy justice framework, it is not enough to simply recognise that some parts of society are suffering using the tenet of distributive injustice. Recognition justice considers marginalised and vulnerable people and any social groups who are unrepresented or misrepresented and asks for greater recognition for these groups (Jenkins et al., 2016). In addition to this, it requires the acknowledgment of divergent perspectives, which are rooted in social, political, ethnic, gender and racial differences (Jenkins et al., 2014). The negative impacts in the energy industry are predominantly borne by the weakest segments of society, that is, poor women and children living and working in close proximity to extractive industry operations (WHO, 2010). For instance, one of the main challenges imposed by fossil fuel industries is the environmental hazard, against which children are more vulnerable than adults, particularly in terms of water and air pollution. They are especially at risk from birth to age 5, a period of rapid physical and mental development (United Nations International Children's Emergency Fund (UNICEF), 2015). In addition, increased gender inequality can result from extractive industry activities. For instance, the extractive industry is typically male-dominated which can exacerbate gender inequality and impose barriers to accessing employment. The negative environmental impacts arising from extractive activities such as change of user or conversion of lands away from traditional uses, can have more impact on women. In many cases, they bear the main responsibility for cultivation of crops and these changes cause great hardship to women who are compelled to seek onerous alternatives to feed their families (Eftimie et al., 2009). When these tasks take more time and effort, women and girls often have less time for other activities such as schooling or other work. In addition, health implications often have greater ramifications for women, in terms of the burden of care for the infirmed (Eftimie et al., 2009).

Indigenous groups, minorities and the poor are other marginalised groups that are more vulnerable to the adverse consequences of fossil fuels activities (Allen, 2001). While they are most exposed to higher levels of pollution and more likely to suffer health impacts, they are generally not responsible for generating the environmental risks (Sovacool et al., 2016). In addition, all these groups are usually left out of community decision-making processes or have little impact on the design of policies (Cameron and Stanley, 2017). Although the potential impacts of extractive industries on local communities, indigenous peoples and women are much better understood now than they were in the past, more proactive action is still required to take preventive and remedial measures to recognise the more vulnerable, underrepresented, and misrepresented people in order to mitigate potential risks that they may face.

2.3 Procedural Justice

Energy justice also asks for the use of fair practices that engage all stakeholders throughout the energy life cycle in a non-discriminatory manner (Heffron et al., 2015). It asserts that those who might be affected by energy decisions should have particular rights to participate and have their voices heard on a fully informed basis (Walker, 2009). Procedural justice is concerned with: process, the equality and transparency of decisions, the adequacy of legal protections, and the legitimacy and inclusivity of institutions involved in decision-making (Sovacool et al., 2016). Various classes in society are treated differentially, with the poor receiving greater physical allocation of the ills of energy infrastructure. So, procedural justice connects with recognition justice when it asks for inclusivity. On the one hand, it means that not only must the participation of the potentially affected communities be taken seriously, but must also include women, the poorest, and indigenous communities. On the other hand, procedural justice relates to the aims of distributive justice such as equity when involuntary resettlement of people has been occasioned (Sovacool et al., 2016).

In addition to effective and inclusive participation, procedural justice seeks for full information disclosure by government and industry. The disclosure of information in the oil, gas and mining sector is vital because the revenues from these activities are colossal and should benefit the citizens. In many cases, lack of transparency leads to diversion of revenues from natural resources through corrupt means especially in developing countries (World Bank, 2003). However, the disclosure of information should not just be limited to the transparency of revenue or how the license or contract is made, which is what international institutions such as the Extractive Industries Transparency Initiative (EITI) tend to do (EITI, n.d.). It must also cover such issues as the potential environmental risks and social impacts of a project that is going to run because it is only through provision of sufficient information that participation would be meaningful. In addition, the identity of decision makers and the decision process should be disclosed. This would enhance responsibility and inclusivity in the energy sector (Natural Resource Governance Institute, 2018). Moreover, in order to have meaningful participation, the disclosed information must be easily accessible and understandable by a non-technical audience (Garthoff, 2010). In sum, this section suggests that the dissemination of the benefits and costs of energy services should be equitably applied across the energy system, the source of energy notwithstanding. The section emphasises that energy justice tenets need to be implemented in the fossil fuel industry as the world transitions to sustainable energysystem operator use.

3 The Right to Remain Silent? Why the Fossil Fuel Industry Needs to Speak and Act on Sustainability

3.1 Oil Dominance and the Benefit of Modern Energy Services

The previous section highlighted the negative impacts of fossil fuels. However, there are counter-arguments that higher emissions and access to the modern and affordable energy services are correlated to lower levels of extreme poverty and inequality (Bersisa, 2017). Therefore, access to modern and affordable energy services is a vital component the in alleviation of poverty and increasing living standards (Ritchie and Roser, 2018). The lack of access to modern energy services is widely known as 'energy poverty' or 'fuel poverty' (IEA, 2018a). Based on the definition by the IEA, these services are measured by household access to electricity and clean cooking facilities (such as fuels and stoves that do not cause air pollution) (IEA, 2018a). It appears unlikely that the global reliance on fossil fuels shall be achieved in the short term because there is a growing energy demand from a burgeoning population growth, which is forecast to rise to 9.8 billion in 2050 and 11.2 billion people in 2100 (UN, 2017).

In 2017, oil was the main energy source used, followed by coal, natural gas, hydro-electricity, and nuclear power (BP, 2018).[12] Renewables were at the bottom of the list. Figure 19.1 clearly demonstrates the complete dominance of fossil fuels, which constituted more than 85% of total energy consumption

[12] Oil 4621.9 mtoe or 98.186 mb/d, coal with 3731.5 mtoe, natural gas with 3156.0 mtoe, hydro with 918.6 mtoe, and nuclear with 596.4 mtoe (BP, 2018).

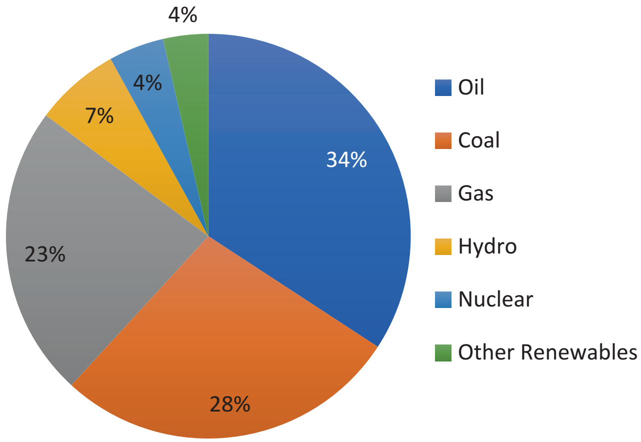

Fig. 19.1 Global primary energy consumption by fuels in 2017. (Source: Adapted from BP, 2018)

in 2017, a situation that is not predicted to radically change anytime soon. It is estimated that, based on known oil reserves and using only today's technology, oil reserves could meet global oil demand through to 2050 (Dale and Fattouh, 2018). Other authoritative global energy outlooks show that a large proportion of global energy needs for the next few decades will be met by fossil fuels which are projected to account for 74–80% of the global energy mix by 2030 (Al-Moneef, 2011). Future advancements in technology and further discoveries, as witnessed by the surge in shale oil and gas development in the US and elsewhere (Cameron et al., 2018), could improve efficiency and buttress the resilience of oil and gas. This can be a cause for either despair or action. Considering this fossil fuel dominance, this chapter argues for the urgent application of energy justice and its tenets to the entire energy industry.

If we believe that justice is the first virtue of social institutions, then no matter how efficient an unjust system is working, it must be reformed (Rawls, 1999). This is the story of the global energy system, which has been linked with diverse inequalities and injustices across the world. One central question to this part of the chapter is: would the exclusion of the fossil fuel industry from energy justice and energy transition strategies be effective? There are three key problems raised here that form the basis for suggesting an answer to this issue: (1) Increased GHG emissions are directly attributed to the fossil fuel industry leading to appeals to divest from them; (2) Fossil fuels are likely to be employed to deal with energy poverty and the need for modern energy services, especially in developing countries; and (3) The dominance of fossil fuels in the global energy mix and predictions of their continued dominance means that they cannot be wished away from the global energy mix. Overemphasising the zero-carbon future while overlooking the present reality is tantamount to unwittingly accepting many other injustices which are associated with fossil fuels. A theory of justice that aims at guiding practical reasoning must address and reduce injustices in any circumstances, rather than aiming only at the characterisation of perfect justice (Sen, 2011: ix).

4 The Energy Trilemma, the Law, and the Fossil Fuel Industry

4.1 Energy Justice and Its Role in the Energy Transition

One common thread in this paper is that, though fundamentally important, energy justice is not simply about transitioning from fossil fuels and reducing emissions. It is not only the fossil fuel industry that is enjoined to operate ethically and fairly but also the sustainable energysystem operator industry. Notably, exploitative renewable energy projects also propagate injustice. It is therefore necessary to mitigate the threat of anthropogenic climate change and transform the economic paradigms that promote global inequality in the energy sector. These changes are achievable through a combination of market forces and policy choices (Committee on America's Energy Future, 2009: 333). The 'energy trilemma' is understood here to capture three fundamental challenges in energy systems: those emanating from economics (affordability), politics (energy security or security of energy supply) and the environment (including climate change and sustainability) (Heffron et al., 2015: 168–169). In this chapter, while the energy trilemma frames the problem and energy justice provides the framework for dealing with these challenges, the just transition to a low carbon global energy system is the common destiny that we should aim for.

There is also a social dimension to the shift from a high-carbon economy to a zero-carbon one; workers and communities that are reliant on the fossil fuel industry are exposed to potential negative impacts associated with the transition (like job loss) (Yeo, 2017). It is necessary to support potentially affected communities and workers from the ramifications of divesting from fossil fuels. Equally, there is value in identifying and reducing inequalities, which now exist in the fossil-fuel life cycle. This does not suggest that the energy transition should be postponed but rather recommends that fossil fuel divestment programs be all-inclusive and circumspect. Establishing medium and long-term strategies for a low carbon energy future is commendable. However, we have to proactively start, from now, identifying and reducing the current inequalities that pervade the fossil-fuel life cycle.

4.2 What Does International Energy Law Have To Do With This?

Few industries can match the global impact that the energy sector has had on human development, global economics, politics, and environmental management (Bradbrook, 2011). There is also a commanding international stake by the fossil fuel industry in the global energy mix and in international energy systems (IEA, 2018d). The combustion of fossil fuels is the greatest contributor to climate change; a cause for global concern as increased anthropogenic CO_2 emissions forecast adverse weather consequences for 2019 (Carrington, 2019). Furthermore, the extractive and fossil fuel sectors are further characterised by: depletion of natural resources, pollution, anthropogenic climate change, inequality, and exclusion (IEA, 2018c). Energy justice and its aim for 'sustainability' has not crystallised into specific laws that exclusively apply to the energy sector. However, the objective of sustainable development, by reducing CO_2 emissions, is captured in various international legal instruments (Segger, 2016: 202). The lack of legal obligations impairs stakeholders from committing to consistent measurable objectives for the energy transition (White, 2013: 213). To this end, we need a comprehensive international legal framework to help us identify and address injustices throughout a fossil-fuel life cycle, determine which affected sections of society are ignored, which processes exist for their remediation in order to reveal, and reduce such injustices (Jenkins et al., 2016).

Energy justice provides the basis for this framework. This chapter also advocates for a harmonised international energy law and policy to be at the core of generating solutions to global energy systems (Heffron, 2015). However, this would need coordinated 'legislation, action and responsibility' in individual regions (Steger, 2010). The law should work for the best interests of all actors and all actors must, in turn, participate in making laws that work for the interest of all.[13] In the oil and gas industry, states and foreign private investors have managed to create mutually beneficial international

[13] See Dixon (2013). Dixon explains, "*Generally speaking, a subject of international law is a body or entity capable of possessing and exercising rights and duties under international law*." Yet, this is somewhat a circular definition, for the answer to the question, '*who has international rights and duties?*' is '*international law*' (Crawford, 2012: 57).

legal arrangements which consist of overlapping regulatory regimes administered by both States and non-State actors (Berman, 2012). This cyclical interdependence between the law and the participants in its formulation, application, interpretation and enforcement should now focus on common good rather than purely reciprocal profitable ventures. There are already some common ways to operationalise legal and energy justice principles that minimise injustices in fossil fuel projects. Environmental impact assessment, social licence to operate, and energy financial reserve obligations are examples of this (Heffron and McCauley, 2017). Moreover, there are some international institutions working with a specific agenda on oil, gas and mining governance, such as EITI and Natural Resource Governance, with considerable success in this way.[14] However, what is clear is that they are not enough. Whereas issues like environmental impacts are taken seriously, other issues like social impacts are not. Little attention has been paid to the legal and regulatory context in which these injustices appear (Jenkins et al., 2017). More importantly, the fossil fuel industry decision-making process should transcend mere cost-benefit analyses and include justice concerns. When governments want to decide whether or not to allow a fossil fuel project, their decision could be better guided by the energy justice framework. Also, other non-state actors in the fossil fuel industry could be, likewise, guided.

5 Conclusion

Energy Justice is not law; rather it articulates principles that analyse the existing energy laws, regulations and policies. More importantly, it develops criteria that guide how the management of energy resources should develop. In light of the adverse effects of anthropogenic climate change, the energy justice tenets elucidated above and the just transition from fossil fuels face many challenges. However, this does not in any way diminish the need for sustainable, just and fair energy systems. Urgent concerted efforts are needed; fiat and antagonistic approaches to dealing with climate change have not been very effective so far. Collaboration between all the actors in the energy system will be key to accelerate the global change necessary.

There are some inherent injustices associated with a fossil fuel-based energy system, which make transition away from fossil fuels inevitable. This chapter appreciates that the desired future is a world with a zero-carbon energy system.

[14] For example, 51 countries are implementing EITI principles, and until today US$ 2.4 trillion worth of revenues have been disclosed (EITI, 2018).

However, the present reality shows that even under the most optimistic scenarios, fossil fuels will remain a considerable part of the global energy mix in the short and medium-term future. Also, it highlighted the counter-argument that, presently, fossil fuels produce abundant, reliable, and affordable modern energy on a global scale. The upshot being that even though a radical immediate shift toward renewables and cutting fossil fuels to zero may be desirable, it may lead to a huge disruption in global development and prevent multitudes from accessing modern energy services. This would frustrate one of the aims of energy justice, the reduction of energy poverty. Thus, this chapter recommends the immediate application of the energy justice framework to the coal, oil and gas sectors. It proposes that the prompt reduction of injustices associated with fossil fuels may be as vital as the plans laid toward the desired low carbon future. Also, it supports the proposition that legal strategies as well as other clear obligations of the respective major players: states, enterprises, and investors are needed in international energy law.[15]

While most discourses analyse different risks associated with fossil fuel activities in either a moral vacuum or pontificate from a judicious podium, this chapter frames it in a more participatory form. Energy justice theory entreats us to put justice at the center of energy decision making processes instead of mere cost-benefit analysis. It is time for all players, including the fossil fuel industry, to do the same if we are to achieve a common global objective; a sustainable energy future for the planet.

References

Allen, D.W. 2001. Social Class, Race, and Toxic Releases in American Counties, 1995. *The Social Science Journal* 38: 13–25.

Al-Moneef, M. 2011. Global Energy Outlook: Challenges and Opportunities for the GCC. In: *The Oil Era: Emerging Challenges*. Abu Dhabi: The Emirates Center for Strategic Studies and Research (ECSSR), p. 18.

Berman, P. 2012. *Global Legal Pluralism: A Jurisprudence of Law Beyond Borders*. Cambridge: Cambridge University Press.

Bersisa, M. 2017. Multidimensional Measure of Household Energy Poverty and Its Determinants in Ethiopia. In: Heshmati, A. (Ed.) *Economic Transformation for Poverty Reduction in Africa: A Multidimensional Approach*. Routledge.

BP. 2018. Statistic Review of World Energy. https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf

[15] For an excellent exposition on this, see Spier (2018).

Bradbrook, A. 2011. Creating Law for Next Generation Energy Technologies. *Journal of Energy & Environmental Law* Winter: 17–38.

Cameron, P.D. and Stanley, M.C. 2017. *Oil, Gas and Mining: A Source Book for Understanding the Extractive Industries*. The World Bank.

Cameron, P., Neira Castro, J-F., Lanardonne, T. and Wood, G. 2018. Across the Universe of Shale Resources—A Comparative Assessment of the Emerging Legal Foundations for Unconventional Energy. *Journal of World Energy Law and Business* 11: 283–321.

Carrington, D. 2019. "Worrying" Rise in Global CO2 Forecast for 2019. *The Guardian*, January 25, 2019. https://www.theguardian.com/environment/2019/jan/25/worrying-rise-in-global-co2-forecast-for-2019.

CNBC Markets. 2018. IEA Report: Global Oil Supply Hit a Record High in August Despite Iran, Venezuela Fallout. https://www.cnbc.com/2018/09/13/iea-global-oil-supply-hits-record-despite-iran-venezuela-fallout.html.

Committee on America's Energy Future. 2009. *America's Energy Future.* National Academies Press, p. 333.

Crawford, J. 2012. Brownlie's *Principles of Public International Law*. Oxford: Oxford University Press.

Dale, S. and Fattouh, B. 2018. Peak Oil Demand and Long-Run Oil Prices. The Oxford Institute for Energy Studies, January 2018. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/01/Peak-Oil-Demand-and-Long-Run-Oil-Prices-Insight-25.pdf.

Devold, H. 2013. Oil and Gas Production Handbook: An Introduction to Oil and Gas Production, Transport, Refining, and Petrochemical Industry (ABB). https://library.e.abb.com/public/34d5b70e18f7d6c8c1257be500438ac3/Oil%20and%20gas%20production%20handbook%20ed3x0_web.pdf.

Dixon, M. 2013. *Textbook on International Law*. Oxford: Oxford University Press.

Eftimie, A., Heller, K. and Strongman, J. 2009. *Gender Dimensions of the Extractive Industries: Mining for Equity*. The World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/18236/511140NWP0extr10Box342018B01PUBLIC1.pdf?sequence=1&isAllowed=y

Extractives Hub. 2017. Environmental Management. https://extractiveshub.org/topic/view/id/7/chapterId/179.

Extractive Industries Transparency Initiative (EITI). 2018. EITI Factsheet. https://eiti.org/sites/default/files/documents/eiti_factsheet_en_feb2018.pdf.

Extractive Industries Transparency Initiative (EITI). n.d. Who We Are. https://eiti.org/who-we-are#aim-of-the-eiti.

Garthoff, J. 2010. Legitimacy Is Not Authority. *Law and Philosophy* 29(6): 669–694.

Global Goals. 2019. Goals 7: Affordable and Clean Energy. https://www.globalgoals.org/7-affordable-and-clean-energy.

Heffron, R. 2015. *Energy Law: An Introduction*. Springer.

Heffron, R.J. and McCauley, D. 2017. The Concept of Energy Justice Across the Disciplines. *Energy Policy* 105: 658–667.

Heffron, R.J., McCauley, D. and Sovacool, B.K. 2015. Resolving Society's Energy Trilemma Through the Energy Justice Metric. *Energy Policy* 87: 168–177.

Intergovernmental Panel on Climate Change (IPCC). 2014. *Climate Change 2014: Mitigation of Climate Change*. Cambridge: Cambridge University Press, p. 1261.

International Energy Agency (IEA). 2015. *The World Energy Outlook Electricity Access Database*. http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/.

International Energy Agency (IEA). 2017. Energy Access Outlook 2017: From Poverty to Prosperity. https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf.

International Energy Agency (IEA). 2018a. Glossary. http://www.iea.org/about/glossary/e/.

International Energy Agency (IEA). 2018b. *Oil Markets Report: September 2018*. https://www.iea.org/oilmarketreport/omrpublic/.

International Energy Agency (IEA). 2018c. Perspective for Energy Transition: The Role of Energy Efficiency. https://webstore.iea.org/perspectives-for-the-energy-transition-investment-needs-for-a-low-carbon-energy-system.

International Energy Agency (IEA). 2018d. *Total Primary Energy Supply (TPES) by Source World 1990–2016*. https://www.iea.org/statistics/?country=WORLD&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES.

Jenkins, K.E.H., McCauley, D., Heffron, R. and Hannes, S. 2014. Energy Justice, A Whole System Approach. *Queens Political Review* 2(2): 74–87.

Jenkins, K.E.H., McCauley, D., Heffron, R., Hannes, S. and Rehner, R.W.M. 2016. Energy Justice: A Conceptual Review. *Energy Research & Social Science* 11: 174–182.

Jenkins, K., McCauley, D. and Forman, A. 2017. Energy Justice: A Policy Approach. In: Jenkins, K., McCauley, D. and Forman, A. (Eds.) Exploring the Energy Justice Nexus: Energy Policy Virtual Special Issue. *Energy Policy*, October 2018.

Liebenthal, L., Michelitsch, R. and Tarazona, E. 2005. *Extractive Industries and Sustainable Development: An Evaluation of World Bank Group Experience*. http://documents.worldbank.org/curated/en/579221468328166526/pdf/32671.pdf.

McCauley, D. 2018. *Energy Justice: Re-Balancing the Trilemma of Security, Poverty and Climate Change*. Palgrave Macmillan.

McCauley, D., Heffron, R., Hannes, S. and Jenkins, K.E.H. 2013. Advancing Energy Justice: The Triumvirate of Tenets and Systems Thinking. *International Energy Law Review* 32(3): 107–116.

McCauley, D., Heffron, R., Pavlenko, M., Rehner, R.W.M. and Homes, R.T. 2016. Energy Justice in the Arctic: Implications for Energy Infrastructural Development in the Arctic. *Energy Research & Social Science* 17: 56–65.

Natural Resource Governance Institute. 2018. Open Contracting for Oil, Gas and Mineral Rights: Shining a Light on Good Practice. https://www.open-contracting.org/wp-content/uploads/2018/06/OpenContracting4EI_Web.pdf.

Ottinger, R., Robinson, N. and Tafur, V. 2005. *IUCN Academy of Environmental Law Research Studies*. Cambridge University Press.

Quéré, C.L., et al. 2018. Global Carbon Budget 2017. *Earth System Science Data* 10(1): 405–448.

Rawls, J. 1999. *A Theory of Justice*, Revised ed. Cambridge, MA: Harvard University Press.

Reig, P., Luo, T. and Proctor, J.N. 2014. Global Shale Gas Development: Water Availability and Business Risks (World Resource Institute). http://wriorg.s3.amazonaws.com/s3fs-public/wri14_report_shalegas.pdf.

Ritchie, H. and Roser, M. 2018. CO_2 and Other Greenhouse Gas Emissions (Our World in Data). https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions#introduction.

Robins, N., Brunsting, V. and Wood, D. 2018. Investing in a Just Transition: Why Investors Need to Integrate a Social Dimension to Their Climate Strategies and How They Could Take Action. https://www.unpri.org/download?ac=4718.

Sari, S., Voyvoda, E., Lacey-Barnacle, M., Karababa, E., Topal, C. and Islambay, D. 2018. Energy Justice: A Social Science and Humanities Cross Cutting Theme Report (Shape Energy, June 2017). https://shapeenergy.eu/wp-content/uploads/2017/09/SHAPE-ENERGY_ThemeReports_ENERGY-JUSTICE.pdf.

Scientific Committee on Health, Environmental and Emerging Risks. 2018. Preliminary Opinion on the Public Health Impacts and Risks Resulting from Onshore Oil and Gas Exploration and Exploitation in the EU. https://ec.europa.eu/health/sites/health/files/scientific_committees/scheer/docs/scheer_o_013.pdf.

Segger, M-C.S. 2016. Advancing the Paris Agreement on Climate Change for Sustainable Development. *Cambridge Journal of International and Comparative Law* 5(2): 202–237.

Sen, A. 2011. *The Idea of Justice*. Cambridge, MA: Harvard University Press.

Smart, I. 1981. Energy and the Public Good. *International Journal* 36(2): 255–272.

Sovacool, B.K. and Dworkin, M.H. 2014. *Global Energy Justice: Problems, Principles, and Practices*. Cambridge: Cambridge University Press.

Sovacool, B.K. and Dworkin, M.H. 2015. Energy Justice: Conceptual Insights and Practical Applications. *Applied Energy* 142: 435–444.

Sovacool, B.K., Heffron, R.J., McCauley, D. and Goldthau, A. 2016. Energy Decisions Reframed as Justice and Ethical Concerns. *Nature Energy* 1: 16–24.

Spang, E., Moomaw, W., Gallagher, K.S., Kirshen, P. and Marks, D.H. 2014. The Water Consumption of Energy Production: An International Comparison'. *Environmental Research Letters* 9: 105002.

Spier, J. 2018. The Principles on Climate Obligations of Enterprises: An Attempt to Give Teeth to the Universally Adopted View That We Must Keep Global Warming Below an Increase of Two Degrees Celsius. *Uniform Law Review* 23(2): 319–335.

Steger, U. 2010. *Sustainable Development and Innovation in the Energy Sector*. Springer.

Stern, N. 2006. *The Stern Review: Report on the Economics of Climate Change*. London: Cabinet Office—HM Treasury.

The World Bank. 2018. New Satellite Data Reveals Progress: Global Gas Flaring Declined in 2017. https://www.worldbank.org/en/news/press-release/2018/07/17/new-satellite-data-reveals-progress-global-gas-flaring-declined-in-2017.

UK Office for National Statistics. 2015. Excess Winter Mortality in England and Wales: 2014/15 (Provisional) and 2013/14 (Final). http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/excesswintermortalityinenglandandwales/201415provisionaland201314final.

UNICEF. 2015. Oil and Gas Scooping Study: UNICEF Extractive Pilot. https://www.unicef.org/csr/files/Oil_and_Gas_Scoping_Paper_19012015.pdf.

United Nations (UN). 2017. World Population Projected to Reach 9.8 billion in 2050 and 11.2 billion in 2100. https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html.

United Nations (UN). n.d. Climate Change. http://www.un.org/en/sections/issues-depth/climate-change/.

United Nations Development Program (UNDP). 2017. Mapping the Oil and Gas Industry to the Sustainable Development Goals: An Atlas—19 July 2017. http://www.undp.org/content/undp/en/home/librarypage/poverty-reduction/mapping-the-oil-and-gas-industry-to-the-sdgs%2D%2Dan-atlas.html.

United Nations Environment Program (UNEP). 1997. Environmental Management in Oil and Gas Exploration and Production: An Overview of Issues and Management. https://wedocs.unep.org/bitstream/handle/20.500.11822/8275/-Environmental%20Management%20in%20Oil%20&%20Gas%20Exploration%20&%20Production-19972123.pdf?sequence=2&isAllowed=y.

United States Environmental Protection Agency (2012). *Report to Congress on Black Carbon* (EPA-450/R-12-001, March 2012). Washington DC: US Environmental Protection Agency.

US Environmental Protection Agency (EPA). 2016. Black Carbon Basic Information. https://www3.epa.gov/blackcarbon/basic.html.

Vaughan, A. 2016. Seven Climate Records Set So Far in 2016–17 June 2016. *The Guardian*. https://www.theguardian.com/environment/2016/jun/17/seven-climate-records-set-so-far-in-2016.

Walker, G. 2009. Beyond Distribution and Proximity: Exploring the Multiple Spatialities of Environmental Justice. *Antipode* 41(4): 614–636.

Watts, J. 2018. Heatwave Sees Record High Temperatures Around World This Week—13 July 2018. *The Guardian* (*US Edition*). https://www.theguardian.com/environment/2018/jul/13/heatwave-sees-record-high-temperatures-set-around-world-this-week.

Weil, P. 1983. Towards Relative Normativity in International Law?. *American Journal of International Law* 77(3): 413–442.

White, M.A. 2013. Sustainability: I Know It When I See It. *Ecological Economics* 86: 213–217.

World Bank Group. 2003. *Striking a Better Balance: The Final Report of Extractive Industries Review*, Vol. 1. World Bank Group.

Wood, Geoffrey (2018). Policy Risk, Politics and Low Carbon Energy. In: Considine, J.L. and Paik, K-W. (Eds.) *Handbook of Energy Politics*. Cheltenham: Edward Elgar Publishing, pp. 425–454.

World Energy Council (WEC). 2015. *Energy Trilemma Index*, February 2015. https://www.worldenergy.org/wp-content/uploads/2015/11/20151030-Index-report-PDF.pdf?

World Health Organization. 2010. Managing the Public health Impacts of Natural Resource Activities: A Framework for National and Local Health Authorities. https://commdev.org/wp-content/uploads/2015/06/WHO-Managing-the-public-health-impacts.pdf.

World Health Organization. 2016. Household Air Pollution and Health (WHO Fact Sheet No. 292 February 2016). http://www.who.int/mediacentre/factsheets/fs292/en/.

Yeo, S. 2017. Clean Energy: The Challenge of Achieving a Just Transition for Workers (Carbon Brief). https://www.carbonbrief.org/clean-energy-the-challenge-of-achieving-a-just-transition-for-workers.

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Fossil Fuel Welfare Versus the Climate

Alex Lenferna

1 Introduction

The framing that the cause of the climate crisis is none other than capitalism has gained significant traction in the climate movement and literature. From the pages of the New York Times declaring that "*it's capitalism stupid*" (Fong, 2017), to one of the climate movements most influential thinkers subtitling her book on climate change *Capitalism vs. the Climate* (Klein, 2014), capitalism is being identified as the underlying drive of the climate crisis. Often central within these critiques is that the heart of capitalist ideology, neoliberal market fundamentalism, has driven and created the climate crisis More specifically, the core idea often seems to be that the main culprit behind climate change is that of free markets and privatisation, coupled with opposition to government intervention, or so the story goes.

There can be no doubt that the business model of rapacious and often corrupt fossil fuel corporations driven largely by quarterly profit are a significant mismatch for a problem like climate change, whose devastating effects could persist and magnify for thousands of years to come. However, while it is true that the way that capital currently functions is undermining the climate, the framing that it is capitalism versus the climate obscures the fact that it is not simply the machinations of some illusory free market that is driving the climate crisis. Rather, the climate crisis would not be where it

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is without a staggering level of government support and welfare handed out to the fossil fuel industry and other polluting interests. What we have is not so much free market capitalism versus the climate, rather it is what is termed here fossil fuel welfare versus the climate.

To be clear, this chapter is not offering an apology for capitalism. Nor is it suggesting that climate change would be resolved if we just returned to something like a free market. Far from it, we have let the climate crisis go unchecked for so long that major state mobilisation will now be required to avert catastrophic climate change and meet even the weaker of the Paris Climate Agreement targets. Additionally, to address the deep inequalities and injustices that underpin the climate crisis, we will certainly require much more than the operation of capital markets to ensure justice and equality. However, we must rid ourselves of the notion that what underpins the climate crisis is the operation of free markets, as the markets that drive the climate crisis are far from free. Instead it is the heavy hand of governments that drive us towards the brink of climate chaos and will also be needed to pull us away from the cliff.

2 Free Market Fundamentalisms and Corporate Power

To understand the point I am making about why free market capitalism may not be the primary driver of the climate crisis more clearly, we can turn to a distinction between two different ways of understanding capitalism highlighted by Richard Moser (2019). The distinction is between free market fundamentalism (FMF) and corporate power. Under the FMF understanding, what drives capital markets is an "*an unregulated free market…* [with] *deregulation, austerity, privatization,* [and] *tax cuts* [which] *undermine the public commons*" (Moser, 2019). This relates to a typical understanding of neoliberalism.[1] The central idea is that neoliberalism is about creating supposedly 'free' markets and protecting them from government interference.

It is this FMF version of capitalism that many have in mind when they engage in the capitalism versus the climate framing, but a more accurate vision of what drives the climate crisis would be Moser's second conception of capitalism as

[1] Defining neoliberalism is a tricky affair, for as Kean Birch (2017: 22) highlights, it is a concept which has been used in many different ways in public discourse. In this paper, I follow its common use as defined by Birch to refer "*to an economic system in which the 'free' market is extended to every part of our public and personal worlds. The transformation of the state from a provider of public welfare to a promoter of markets and competition helps to enable this shift*".

corporate power. Moser argues that the free market is often a less powerful a driver of capital, and instead what we face is a new form of capitalist order, what he terms 'corporate power'. Corporate power, as Moser argues, is "*the merger between the biggest corporations and the state*" where the power of the state is used to serve the corporation rather than the people. Under this new capitalist order, the state increasingly uses its power to protect the interests of major corporations, whether through violence, subsidies, protective regulation and other preferential measures.

As Moser further argues, the emphasis that many put on the FMF version of capitalism has unwittingly contributed to "*the deeply rooted mythic aura of free markets*", and by doing so obscured the nature of corporate power. Likewise, when it comes to climate change, the fossil fuel industry is able to continue to be one of the most profitable and destructive industries on earth not by the machinations of mythical free markets, but rather by corporate power—by merging with the state and using the power of the state to protect corporate interest.

While Moser's 'corporate power' label provides us with an important distinction which moves us away from a FMF understanding of capitalism, I find it too ambiguous. Corporate power, to the lay reader, could be easily read as referring to the power that corporations have, rather than singling out the role that the state plays in propping up the fossil fuel industry. As such, because I am interested in developing a label that is emotive and easily recognisable, in this piece I instead use the term fossil fuel welfare versus the climate. The aim of using this label is to highlight the active involvement of the state in supporting the industry.[2]

Indeed, far from being defenders of capitalism and the competitive winners in the free market, the fossil fuel industry is perhaps one of the biggest beneficiaries of an egregious amount of government welfare, which makes the public foot the bill for their harmful and increasingly uncompetitive industry. Governments the world over favour fossil fuel interests through rigged capital markets, public financing, financial subsidies, bailouts and corrupt governance systems. To hide this system of corporate welfare, the fossil fuel industry has invested in a wide-scale public relations scheme (read: propaganda campaign) to paint themselves as the defenders of the free market (Conway and Oreskes, 2010; McKinnon, 2016).

[2] I do not use the fossil fuel welfare versus the climate framing because I believe welfare is a dirty word, although purported supporters of free market fundamentalism often treat it as such. Rather, the aim of calling it fossil fuel welfare is to turn the stigma that free market fundamentalists have tried to create around welfare and direct the stigma towards the fossil fuel industry, by showing how state protection underpins the fossil fuel industry business model. Welfare, then, is not a dirty word, but when welfare is used to prop up a dirty, destructive industry, it becomes a dirty practice.

While many are aware of the multiple investigations revealing the fossil fuel industry's decades-long climate science misinformation campaign, less attention has been paid to how fossil fuel interests have used propaganda to successfully spread the lie that attacks on the fossil fuel industry are attacks on capitalism itself (Banerjee, 2017). Climate science misinformation is deeply intertwined with ideological misinformation, where fossil fuel apologists falsely paint themselves as the defenders of freedom and capitalism. Fossil fuel propagandists have even, quite successfully, tried to dupe Evangelicals into associating the fossil fuel industry with the free market, and the free market with God's will (O'Connor, 2017). Thus, attacks on the fossil fuel industry become attacks on God's will itself. But if God's will was really aligned with the free market, then the fossil fuel industry would be doing the devil's work.

3 International Case Studies of Fossil Fuel Welfarism

To examine the depth and scale of fossil fuel welfare, this chapter examines case studies of the world's worst polluting nations. Consider, for instance, the author's home country of South Africa, Africa's biggest greenhouse gas polluter. South Africa used to be home to the world's fastest growing renewable energy sector—thanks to an innovative private sector investment program (Burkhardt, 2018). However, Eskom, the country's *public* utility, sabotaged the renewables boom, and the government actively intervened to slow down the uptake of renewable energy (Sharife, 2010). A corrupted desire to pursue uncompetitive nuclear power and protect coal interests ground the renewables investment program to a halt. The South African Government did that despite the fact that renewables were greatly outcompeting fossil fuels, saving South Africa billions every year (Calitz et al., 2015).

Far from capitalism versus the climate, in South Africa it has been government cronyism versus capital interests that aligned with the climate. Additionally, it has been resistance from labour unions to the operation of private capital that has slowed the transition to renewable energy. Mining and metalworker unions, who are some of South Africa's most powerful political forces, have opposed the roll out of privatised renewable energy out of understandable fear of losing their jobs and not being protected in the transition to renewable energy (Fakir, 2018). Fear of losing out in the transition in a deeply unequal and poverty-stricken country like South Africa, has been one of the major obstacles to rolling out a more affordable and stable renewable energy economy. As such, we see that in South Africa, it is less free markets, and more state protectionism, artificially subsidising coal through tariff increases, and a lack of plans for a just transition, which protects coal and jeopardises the climate.

Let us now turn to Saudi Arabia and Russia, respectively the world's largest oil and 'natural' (or rather fracked) gas exporters. Both countries have long blocked progress on climate change within the UN climate negotiations, and form part of a handful of the worst polluting nations whose climate actions are ranked as "*critically insufficient*" (Climate Action Tracker, 2018). Saudi Arabia and Russia both have lavish government support and subsidies for their state-owned oil and gas companies—an arrangement that can hardly be described as adhering to free market economics. Seemingly inspired by Putin and the Saudi Royal Family, Canada, the world's dirtiest oil producer, is moving to nationalise tar sands oil pipelines. More specifically, Prime Minister Justin Trudeau has instructed the Canadian government to step in to buy and nationalise the Trans Mountain tar sands pipeline. Trudeau did so despite widespread public resistance and despite the fact that oil and gas pipeline company, Kinder Morgan, who initially owned the project, thought the project was too financially risky to proceed with (McKibben, 2018).

The next major polluter is down under, Australia, the world's largest coal exporter and one of the highest per capita carbon polluters, ranked last in the world on climate action out of all nations, according to the Sustainable Development Goals Index (Lenferna, 2018). Alongside the over $10 billion in tax-based fossil fuel subsidies Australia provides to the fossil fuel industry (Market Forces, 2018), the government is increasingly attempting to prop up an uncompetitive fossil fuel industry. The federal government is moving to underwrite the coal industry to protect them from losses, making it such that the public would have to foot the bill for potentially billions of dollars of losses from the coal industry (Murphy, 2018). Australia's federal government is also working hard to provide major subsidies and state support to foreign multinational coal mining companies. In addition to virtually limitless water supply, the federal government is desperately trying to use taxpayer money to finance the opening of the largest coal mine in the Southern Hemisphere, the proposed Adani Carmichael coal mine, even though all major banks have declined to finance the project (Ritter, 2018; Slezak, 2017). In the words of the Australia Institute's Chief Economist Richard Denniss (2018):

> Australian politics isn't about ideology, it's about interests. The clearest proof of that claim is that neoliberal ideas such as deregulation were never aimed at powerful interest groups like the pharmacists or the gambling industry. And savage spending cuts were never aimed at subsidies for the fossil-fuel industry or private health insurers.

Denniss' point, that neoliberal ideology is hypocritically and unevenly applied, is really central to the climate crisis, where we have generous big government support for the fossil fuel industry, and harsh neoliberalism and austerity for people and the planet. Dennis's quote gets to the heart of what I am arguing in this chapter, insofar as it points out that a central driver of the climate crisis is how the state has been hijacked to serve the interests of large polluting corporations who are driving climate change, rather than to serve the interest of people and planet. It is a dynamic that plays out not only in countries that claim to be capitalists, but also in states who more openly embrace the role of the state, including the world's biggest current greenhouse gas (GHG) polluter, namely, China.

China's unparalleled fossil fuel boom was driven by a mix of capitalism and communism with the state playing a major driving role in the build-out of the most rapid expansion of fossil fuel infrastructure the world has seen (Smith, 2015). Now, in an attempt to turn that massive economy around, a similar mix of capitalism and communism is playing out in China's dramatic state-led U-turn towards renewable energy (Orvis, 2014). To help fathom the scale of their shift we can reflect on the fact that China will build enough renewable energy to meet the equivalent of all of the United States' energy needs within just two decades.

Of course, no survey of the world's largest polluters would be complete without turning to the United States (US), the world's largest historical GHG polluter. The US is often slated as the defender of capitalism. However, it would be a stretch to argue that the fossil fuel industry is thriving because of its competitive capitalist edge. Rather, as Noam Chomsky (2013: 77–78) argues, US has "*never had capitalism, so it can't end*". Instead, Chomsky argues that US has a variety of state capitalism, where the government actively props up and supports certain industries. This holds especially true in relation to the fossil fuel industry where state capitalism is increasingly descending into corrupt crony capitalism or what I am terming fossil fuel welfarism.

Consider a report revealing that US tax payers foot the bill for US$20 billion in fossil fuel subsidies each year, with 80% going to oil and gas, and coal receiving the other 20% (Redman, 2017). Put in perspective, recent International Monetary Fund estimates suggest that the US spends ten times more on fossil fuel subsidies than it does on education (Ellsmoor, 2019). Without those lavish subsidies, the fossil fuel industry would be in deep trouble. Studies show that without such subsidies half of future oil production in the US would be unprofitable (Erickson et al., 2017). As for coal, even the

Wall Street Journal admits that coal simply "*can't compete on a true level playing field*", and is losing out despite its major subsidies (Resesz, 2017). A recent study showed that without regulation to shield them from market forces, about half of the coal plants in the US would be heading towards bankruptcy, as they did not earn enough revenue in 2017 to even cover their operating expenses (Ryan, 2018).

Even fracking for gas, the supposed poster child of US fossil fuel capitalism and innovation, is being kept afloat largely because of handouts and tax breaks. As Justin Mikulka (2018) reported, the tax law that the Republican Party passed in 2017 helped bail out fracking companies who were losing money and taking on mountains of debt. Shale oil frackers have long been losing more money than they make. From 2007–2017 they spent US$280 billion more than they generated from operations on shale investments (Olson and Cook, 2017). The fracking industry is swamped by debt and is running a business model some commentators argue represents a ponzi scheme of bad debt (Forrest, 2016). As Mikulka argues, it is largely due to the Trump Administration coming in to bail them out, that the frackers were able to avoid the scheme collapsing further than the already wide-spread bankruptcies of the previous few years (Sider, 2015).

4 Fossil Fuelled False Consciousness

The line that is often sold to justify fossil fuel welfare policies is that doing so protects fossil fuel workers and jobs, but protecting corporate profits is very different from protecting workers. Returning to the US context, while the Trump Administration and Republican Congress work to provide the fossil fuel industry with corporate welfare, fossil fuel executives are giving themselves large raises and bonuses, cashing in company stock options, and even betting on their own company's failure right before they drive their companies into the ground. Workers meanwhile are often being left in the dirt.

As a New York Times investigation revealed, from 2004 to 2016, the average annual wage for chief executives in the coal industry grew as much as five times faster than those of lower-paying jobs in the industry, like construction or truck and tractor operator jobs (Tabuchi, 2017a). While executive pay rose by 60%, the wages of truck and tractor operators barely kept up with inflation, while the wages for construction workers failed to keep up with inflation altogether, resulting in an effective pay cut of about US$6,000. It would be one thing if execs were rewarding themselves with pay increases for their good work, but their pay increases often came as they were running the companies into the ground, leading to widespread bankruptcies across the US coal industry.[3]

What's worse, before the onset of widespread bankruptcies, coal execs continued to talk up the ongoing viability of industry and to invest their companies into further expansions (Anderson et al., 2015). However, analysis of SEC filing shows that behind the scenes those same coal execs cashed in well over US$100 million in stock options, often short-selling their own companies, providing pretty clear signs that they were betting on the decline of their own industry, all the while pretending in public that the future of the companies was fine, thus putting at risk workers' livelihoods and shareholder value.

While coal company execs were seemingly rewarded for driving their companies into the ground, it seems they were punishing workers as if it was somehow their fault. For instance, Alpha Natural Resources gave their execs multi-million dollar bonuses, while laying off thousands of workers, and cutting the health, life insurance, and retiree benefits of the workers that remained. They were not alone in doing so either with many major coal companies richly rewarding their execs while stiffing their workers (Roberts, 2016).

Revealing Trump's faux-populism and false promises to coal workers, instead of helping coal mining communities as their industry slumps, Trump's first budget proposal sought to slash funding to key programs aimed at promoting economic development in coal regions, including the Appalachian Regional Commission and the Economic Development Administration (Lenferna, 2017). As analysis by the Center for American Progress shows, these programs have been key in supporting coal communities that have been left behind as mining jobs vanished (Bassett and Walsh, 2017). Gutting them as Trump plans to do, could further devastate coal communities.

Even Trump's attempts to eliminate Obama's Clean Power Plan may leave coal workers further stranded. Part of Obama's efforts included the Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) Initiative (Office of the Press Secretary, 2016). The initiative aimed at providing economic and workforce development programs and resources to assist communities and workers that have been affected by job losses in the coal industry. This formed part of the POWER + PLAN which would have

[3] While coal executives and the Trump Administration have blamed regulation for the decline that was seen in the U.S. coal industry, studies suggest that this is a false narrative. As a study developed by economists from Columbia University showed, regulation was responsible for only 3–5% of coal's decline from 2008 until 2016, during the term of Obama's presidency (Houser et al., 2017). The decline came instead predominately from coal executives failing to properly plan for reduced demand and competition from renewables and fracked gas i.e. capital forces predominately killed coal.

leveraged US$8 billion in investments for coal communities. Trump's attempts to unravel Obama's climate legacy will thus leave coal workers high and dry, while economic forces continue to drive the decline of their industry (cf. Houser et al., 2017).

Unlike places like Germany where a robust social safety net and retraining programs for fossil fuel workers has helped smooth their clean energy transition, in the US, keeping workers in a state of precarity is used as a strategy to help spur resistance to a fossil fuel transition (Dolsak and Prakash, 2016; Zaffos, 2016). Rich fossil fuel executives and bought-off politicians prey on the suffering of fossil fuel workers to fatten their already heavily padded wallets, all the while causing egregious pollution and putting the very stability of the earth's climate at stake.

To borrow some terminology from Marxist scholars (cf. Eyerman, 1981), the fossil fuel industry is using mass culture and propaganda to create a 'false consciousness', whose aim is to trick the working class (or the proletariat) into thinking that its interests are aligned with fossil fuel corporations, even as those corporations leave their workers hanging out to dry. Such a reality suggests that instead of capitalism vs. the climate, a better way of framing the climate crisis would draw on the words of Martin Luther King Jr. who decried that the US "*has socialism for the rich, rugged individualism for the poor*". In the climate case, the US, like South Africa and many parts of the world, has socialism for rich fossil fuel industry companies and executives, and harsh unforgiving individualism for fossil fuel workers.

The examples I have provided from across the globe demonstrate, what is in some ways a rather simple point, that it is not simply FMF capitalism versus the climate, but rather both capitalist and non-capitalist policies and systems of governance can favour fossil fuel interests. It is not simply a free market that drives the climate crisis. Rather, rigged markets which favour pollution and fossil fuels are one of the dominant driving factors behind the climate crisis. One of our most important tasks, if we are to address climate change at the scale needed, is to re-rig markets, regulations, and governance systems which currently favour polluters, so that instead they work to promote the public interest or the common good.

5 Bootstrapping up an Unlevel Playing Field

Globally, the scale of the fossil fuel industry's welfare is astounding. Even if we do not take into account the trillions of dollars' worth of harmful externalities that the industry foists onto the public each year, the International Monetary

Fund estimates that eliminating fossil fuel subsidies could free up US$2.9 trillion in government revenue annually (Clements et al., 2013). That is more than double the US$1.25 trillion in estimated annual investment needed in renewable energy and energy efficiency that would be needed globally by 2035 to keep warming to 2°C, according to the International Energy Agency (IEA) (Evans, 2014). To meet the much safer and more just target of keeping warming to 1.5°C would only require an additional $460 billion per year according to a study in *Nature Energy* (McCollum et al., 2018). So, if all fossil fuel subsidies were re-invested in a low-carbon future, we would have more than enough money to meet the 1.5°C target, provided we have not delayed action too long already to do so (IPCC, 2018).

Remarkably, while the fossil fuel industry receives astronomical amounts of welfare, fossil fuel industry lobbyists and talking heads hypocritically demand renewable energy pull itself up from its bootstraps (Lacey, 2012). They decry subsidies for renewable energy as the government picking winners and losers, conveniently glossing over the fact that the fossil fuel industry's corporate welfare wildly outnumbers the meagre subsidies the renewable energy sector gets. For instance, studies by the IEA point out that global subsidies for fossil fuels outstrip those for renewable energy nearly 10-fold, and if we include their environmental externalities, we can add at least another 10-fold (Parkinson, 2016).

It is this deeply unlevel playing field that keeps the fossil fuel industry afloat and renewable energy from taking off. In the words of Amory Lovins (2016), the world-renowned energy expert who helped engineer China's renewable energy revolution, "*worldwide, renewables in fair competition (no subsidies and no corruption) generally cost less than any other new electricity source and many existing ones*". Despite all the roadblocks it faces, renewable energy is still getting out ahead of fossil fuels, such that two Australian engineering researchers recently calculated that if renewable energy continues growing at current rates it could put the *entire* world on track "*to reach 100% renewable electricity by 2032*" (Blakers and Stocks, 2018). The only thing holding us back from this, they argued, would be politics, and the political obstacles are substantial.

While the fossil fuel industry is given a huge hand up by the government, the innovative and entrepreneurial spirit of citizens who want to produce their own renewable energy and sell it back to others is often being stifled by utilities and governments. Net metering policies allowed citizens to sell their energy back to the grid. However, rather than cheering on this entrepreneurial spirit, in many places the remarkable growth in renewables that such policies created has come to "*a shuddering halt*" due to "*a concerted and well-funded lobbying campaign by traditional utilities*" to kill net metering policies (Tabuchi, 2017b). In response, libertarian free market advocates, who see through fossil fuel industry propaganda, are starting to rail against utilities and big governments' attempts to kill solar and other renewables (Smith, 2013).

It is a sign of our Orwellian times, a remarkable display of double think, that Republicans and right-wing self-professed conservatives who claim to be adherents of the free market and conservativism are the one's defending the fossil fuel industry's grotesque corporate socialism and shielding them from competition. It should be no surprise though, for if we follow the money we see that the fossil fuel industry has given 91 percent of their immense campaign contributions to Republicans (Lavelle, 2016). The campaign contributions seem to have caused an acute form of politician-Amnesia, for just 10 years ago the Republican party accepted climate science and claimed to support climate action. Then the Citizens United ruling lifted the limits on campaign spending and fossil fuel money flowed, corrupting an entire political party (Whitehouse, 2018). Indeed, the partisan divide on climate change did not simply arise out of the cultural milieu or derive from some principled ideological commitment. Rather, it was largely created, funded, and stoked by the propaganda and corruption arms of vested fossil fuel interests.

Part of the danger of the capitalism vs. the climate framing is that by failing to name the immense welfare underpinning the fossil fuel industry, it plays into the hands of the fossil fuel industry propaganda machine. Alternatively, if we insist on the framing of capitalism vs. the climate, let us name the sort of capitalism that we are fighting—a corrupt crony capitalism which makes the public foot the bill for massive corporate welfare handouts to the richest and most destructive industry on earth, while often applying neoliberal austerity to fossil fuel workers and the renewable energy industry. Perhaps some would argue that that is exactly what they mean when they say capitalism vs. the climate, but if so, let us say so more explicitly, because to those surrounded by fossil fuel industry propaganda, capitalism may sound more like markets free of corrupt government intervention.

5.1 Degrees of Socialism

There is also an additional problem with the idea that capitalism is the problem and, what is often taken to be the correlate, that socialism is the answer. The problem is there simply is not enough time or the requisite social base to institute wide-scale socialism in time to address the climate crisis, at least not of the full-blown Marxist-Leninist version where we transform the economy from where it is now to one where we have social ownership of the means of production. In the words of Noam Chomsky (2013: 170), "*If we're talking about feasible objectives in the short term, it's kind of meaningless to talk about socialism. There isn't a popular base for it. There isn't an understanding of it*". Similarly, Jacobin magazine, one of the leading socialist press outlets, warns against thinking that the way to solve climate change is to enact socialism:

> If capitalism is driving climate change, does that mean we need a revolution to stop it? We should hope not. The Left's vision of radical transformation can seem like an obvious match for the climate challenge. But the Left remains historically weak and a return to real power on the scale required isn't likely anytime soon—certainly not on the timescale we need to start taking serious action. We can't shortcut the long-term project of building socialism—but nor can we side line climate action along the way. Otherwise, even in the best-case scenario, the Left will win power only to manage a state of increasing climate breakdown. So no matter how necessary a break with capitalism is, for now we'll have to settle for addressing climate change as best we can within it. (Battistoni, 2017: 9)

While Chomsky and Battistoni both advocate for a form of socialism in the long-run, they provide much needed caution against thinking that a full-blown socialist revolution is the short-term answer to climate change given the incredibly short time remaining to tackle the climate crisis. However, while we may not have time to enact a Marxist utopia and to reclaim all the means of production, an all-or-nothing approach to socialism is arguably not a particularly helpful way of framing our response to climate change.

As philosopher Ann Ferguson (2018) argues, socialism from a feminist perspective is not an all or nothing blueprint, but rather a vision of degrees of power/freedom that people in a particular society have in economic, political, social and personal relations. Taking Ferguson's spectrum view of socialism into account, what we have now is a deeply impoverished form of corrupted corporate socialism which empowers the fossil fuel industry. We might not have time to implement a robust full-blown socialism, where one seizes and nationalises private corporations, but we can shift the degree of socialism away from fossil fuel corporations and towards people and planet. Indeed, it is long past time we dismantled the fossil fuel industry's corporate socialism and redirect the immense state support the fossil fuel industry receives to social goals that are beneficial such as a just transition towards a renewable energy future.

Once we recognise the extent of fossil fuel welfare, then we can see that often we may not necessarily need to grow government but rather to redirect government so that its hand is there to help people and planet not fossil fuel corporations. Instead of public subsidies and government support for polluting activities that is putting the entire planet at risk, we urgently need to redirect the immense government support given to the fossil fuel industry to the sort of future we actually want: a just transition to a more equitable and prosperous renewable energy future, which puts the interests of people and planet over that of fossil fuel corporations. If we do so, we might have a fighting chance to avert the worst ravages of climate change and create a much better world while doing so.

Even in the US, the heart of climate disinformation, fossil fuel propaganda, and the supposed home of capitalism, polling shows widespread support for policies associated with a Green New Deal, which involve an ambitious state-led mobilisation including large public investments and public-private partnerships (Kaufman, 2018). The surging popularity of politicians such as Alexandria Ocasio-Cortez, Bernie Sanders and Jeremy Corbyn also demonstrate growing openness to create a society whose hand is aimed not at propping up fossil fuel corporations but rather to benefit social and ecological welfare. Similarly, as George Monbiot (2017) convincingly argues in his book *Out of the Wreckage*, energised campaigns around such a vision of government to favor people and planet may also provide one of the few robust enough visions to counter the rising waves of right-wing fascist politics which themselves have deep ties to the corporate interests which benefit from the fossil fueled status quo. Thus, moving away from fossil fuel welfare and corporate socialism, it is past time that we reclaimed our governments and used them to support the sort of future we actually want, before it is too late.

6 Conclusion

To conclude, the extent of fossil fuel welfare and government protectionism is immense, so much so that by simply redirecting the fossil fuel industry's subsidies to climate action we could meet even the Paris Climate Agreement stronger target of 1.5°C. Recognising this reality, instead of the public subsidising an industry undermining the health of people and ecosystems the world over, and dangerously destabilising the global climate system, we urgently need to redirect the immense government support given to the fossil fuel industry to the sort of future we actually want: a just transition to a more equitable and prosperous clean energy future, which puts the interests of people and planet over that of fossil fuel corporations. It is time we shifted from fossil fuel welfare vs. the climate, to a welfare system aimed at promoting social and ecological well-being.

References

Anderson, S., Collins, C. and Pizzigati, S. 2015. *Executive Excess 2015: Money to Burn*. Washington, DC. https://ips-dc.org/wp-content/uploads/2015/09/EE2015-Money-To-Burn-Upd.pdf.

Banerjee, N. 2017. How Big Oil Lost Control of Its Climate Misinformation Machine. *Inside Climate News*. https://insideclimatenews.org/news/22122017/big-oil-heartland-climate-science-misinformation-campaign-koch-api-trump-infographic.

Bassett, L. and Walsh, J. 2017. *The Trump Budget Cuts Hit Coal Communities and Workers Where It Hurts*. Washington, DC. https://www.americanprogress.org/issues/green/reports/2017/04/24/430842/trump-budget-cuts-hit-coal-communities-workers-hurts/.

Battistoni, A. 2017. Within and Against Capitalism. *Jacobin*, 910. https://jacobinmag.com/2017/08/within-and-against-capitalism.

Birch, K. 2017. What Exactly Is Neoliberalism? *The Conversation*. https://theconversation.com/what-exactly-is-neoliberalism-84755.

Blakers, A. and Stocks, M. 2018. Solar PV and Wind Are on Track to Replace All Coal, Oil and Gas within Two Decades. *The Conversation*.

Burkhardt, P. 2018. Revealed! How Brian Molefe Sabotaged SA's World-Class Renewables Industry. *BizNews*.

Calitz, J., Mushwana, C. and Bischof-Niemz, T. 2015. *Financial Benefits of Renewables in South Africa in 2015: Actual Diesel- and Coal-Fuel Savings and Avoided "Unserved Energy" from the First Operational 1.8 GW of Wind and PV Projects in a Constrained South African Power System*. http://www.csir.co.za/media_releases/docs/FinancialbenefitsofWindandPV2015.pdf.

Chomsky, N. 2013. *Power Systems: Conversations on Global Democratic Uprisings and the New Challenges to U.S. Empire*. Interviews. New York: Metropolitan Books.

Clements, M., Coady, D. and Fabrizio, M. 2013. Energy Subsidy Reform: Lessons and Implications. *International Monetary Fund* (iii): 68. http://books.google.com/books?hl=en&lr=&id=NYi1AQAAQBAJ&oi=fnd&pg=PP2&dq=ENERGY+SUBSIDY+REFORM+:+LESSONS+AND+IMPLICATIONS&ots=4saeQWH9da&sig=dm4_xQDUGapysuN1PCO3mbUJB_g.

Climate Action Tracker. 2018. Countries. *Climate Action Tracker*, December 12, 2018. https://climateactiontracker.org/countries/#.

Conway, E.M. and Oreskes, N. 2010. *Merchants of Doubt*. New York: Bloomsbury Press.

Denniss, R. 2018. The Big Con: How Neoliberals Convinced Us There Wasn't Enough to Go Around—Sun 3 June 2018. *The Guardian*. https://www.theguardian.com/australia-news/2018/jun/04/the-big-con-how-neoliberals-convinced-us-there-wasnt-enough-to-go-around.

Dolsak, N. and Prakash, A. 2016. We Feel Your Pain: Environmentalists, Coal Miners, and 'Embedded Environmentalism'. *Solutions* 7(1): 32–37. https://www.thesolutionsjournal.com/article/we-feel-your-pain-environmentalists-coal-miners-and-embedded-environmentalism/.

Ellsmoor, J. 2019. United States Spend Ten Times More On Fossil Fuel Subsidies Than Education. *Forbes*. https://www.forbes.com/sites/jamesellsmoor/2019/06/15/united-states-spend-ten-times-more-on-fossil-fuel-subsidies-than-education/.

Erickson, P., Down, A., Lazarus, M. and Koplow, D. 2017. United States Crude Oil Production. *Nature Energy* 2(November). https://doi.org/10.1038/s41560-017-0009-8.

Evans, S. 2014. IEA: The Marginal Cost of Two Degrees. *Carbon Brief*.

Eyerman, R. 1981. False Consciousness and Ideology in Marxist Theory. *Acta Sociologica* 24(1/2): 43–56. https://www.jstor.org/stable/4194332.

Fakir, S. 2018. The Just Transition Debate in South Africa. *Engineering News*. https://www.engineeringnews.co.za/article/the-just-transition-debate-in-south-africa-2018-05-18.

Ferguson, A. 2018. Socialist-Feminist Transitions and Visions. *Radical Philosophy Review* 21(1): 177–200.

Fong, B-Y. 2017. The Climate Crisis? It's Capitalism, Stupid. *The New York Times*. https://www.nytimes.com/2017/11/20/opinion/climate-capitalism-crisis.html.

Forrest, D. 2016. Low Oil Prices Are Not The Reason Oil Companies Are Going Bankrupt. *Oil Price*. https://oilprice.com/Energy/Energy-General/Low-Oil-Prices-Are-Not-The-Reason-Oil-Companies-Are-Going-Bankrupt.html.

Houser, T., Bordoff, J. and Marsters, P. 2017. *Can Coal Make a Comeback?* https://energypolicy.columbia.edu/sites/default/files/Center_on_Global_Energy_Policy_Can_Coal_Make_Comeback_April_2017.pdf.

IPCC. 2018. IPCC Special Report on the Impacts of Global Warming of 1.5 °C—Summary for Policy Makers (October 2018). http://www.ipcc.ch/report/sr15/.

Kaufman, A. 2018. 2018's Voters Support Green Jobs Guarantee And Climate Polluter Fees: Poll. *Huffington Post*. https://www.huffingtonpost.com/entry/green-new-deal-poll_us_5beb03a5e4b044bbb1a98559?ncid=tweetlnkushpmg00000067.

Klein, N. 2014. *This Changes Everything: Capitalism Vs. The Climate*. New York: Simon & Schuster.

Lacey, S. 2012. Free-Market Hypocrisy: Why Do We Hold Renewables to Different Standards? *Grist*. https://grist.org/climate-energy/free-market-hypocrisy-why-do-we-hold-renewables-to-different-standards/.

Lavelle, M. 2016. Fossil Fuel Money to GOP Grows, and So Does Climate Divide. *Inside Climate News*. https://insideclimatenews.org/news/15092016/fossil-fuel-funding-gop-grows-climate-divide-republican-donald-trump-hillary-clinton.

Lenferna, G.A. 2017. Don't Believe Trump—The Fossil Fuel Era Is Ending, the Real Question Is How Fast. *Medium*. https://medium.com/@AlexLenferna/dont-believe-trump-the-fossil-fuel-industry-is-going-under-the-real-question-is-how-fast-505b116dda24.

Lenferna, A. 2018. Australia's Fossil Fuel Export Trilemma. *Renew Economy*.

Lovins, A. 2016. Nuclear No Match for Renewables. https://nuclearcostssa.org/nuclear-no-match-for-renewables/.

Market Forces. 2018. Public Money Propping Up Fossil Fuels. *Market Forces*, August 30, 2018. https://www.marketforces.org.au/campaigns/ffs/z.

McCollum, D.L. et al. 2018. Energy Investment Needs for Fulfilling the Paris Development Goals. *Nature Energy* 3(July). https://doi.org/10.1038/s41560-018-0179-z.

McKibben, B. 2018. Say Hello to Justin Trudeau, the World's Newest Oil Executive. *The Guardian*.

McKinnon, C. 2016. Should We Tolerate Climate Change Denial? *Midwest Studies in Philosophy* XL: 205–216.

Mikulka, J. 2018. GOP Tax Law Bails Out Fracking Companies Buried in Debt. *Desmog*. https://www.desmogblog.com/2018/04/26/gop-tax-law-bails-out-fracking-companies-debt-eog-hamm?utm_source=dsbnewsletter.

Monbiot, G. 2017. *Out of the Wreckage: A New Politics for an Age of Crisis*. Vero.

Moser, R. 2019. Neoliberalism: Free Market Fundamentalism or Corporate Power? *Counterpunch*. https://www.counterpunch.org/2019/01/11/neoliberalism-free-market-fundamentalism-or-corporate-power/.

Murphy, K. 2018. Underwriting Coal Power Exposes Taxpayers to Billions, Industry Group Says. *The Guardian*. https://www.theguardian.com/australia-news/2018/nov/16/underwriting-coal-power-exposes-taxpayers-to-billions-industry-group-says.

O'Connor, B. 2017. How Fossil Fuel Money Made Climate Change Denial the Word of God. *Splinter*. http://splinternews.com/how-fossil-fuel-money-made-climate-denial-the-word-of-g-1797466298.

Office of the Press Secretary. 2016. Administration Announces New Economic and Workforce Development Resources for Coal Communities Through POWER Initiative. *The White House*, August 24, 2016. https://obamawhitehouse.archives.gov/the-press-office/2016/08/24/fact-sheet-administration-announces-new-economic-and-workforce.

Olson, B. and Cook, L. 2017. Wall Street Tells Frackers to Stop Counting Barrels, Start Making Profits. *Wall Street Journal*. https://www.wsj.com/articles/wall-streets-fracking-frenzy-runs-dry-as-profits-fail-to-materialize-1512577420.

Orvis, R. 2014. What China's Climate Commitment Means for Its Electricity Sector. *Greentech Media*.

Parkinson, G. 2016. The Myth About Renewable Energy Subsidies. *Clean Technica*.

Redman, J. 2017. *Dirty Energy Dominance: Dependent on Denial—How the U.S. Fossil Fuel Industry Depends on Subsidies and Climate Denial*. http://priceofoil.org/content/uploads/2017/10/OCI_US-Fossil-Fuel-Subs-2015-16_Final_Oct2017.pdf.

Resesz, R.L. 2017. Why Coal Can't Compete on a True Level Playing Field. *Wall Street Journal.*

Ritter, D. 2018. *The Coal Truth*. Crawley: UWA Publishing.

Roberts, D. 2016. What Do You Give Executives Who Bankrupted a Coal Company and Screwed over Its Retirees? Bonuses! *Vox*. https://www.vox.com/2016/1/25/10827928/alpha-bankruptcy-executive-bonuses.

Ryan, J. 2018. Half of All U.S. Coal Plants Would Lose Money Without Regulation. *Bloomberg*.

Sharife, K. 2010. South Africa's Dirty Secret: Eskom and the Medupi Power Plant. *Huffington Post*. http://www.huffingtonpost.com/khadija-sharife/south-africas-dirty-secre_b_576996.html.

Sider, A. 2015. Fracking Firms That Drove Oil Boom Struggle to Survive. *Wall Street Journal*. https://www.wsj.com/articles/fracking-firms-that-drove-oil-boom-struggle-to-survive-1443053791.

Slezak, M. 2017. Adani Coalmine Project: China Construction Bank Won't Grant Loan, PR Firm Says. *The Guardian*.

Smith, S. 2013. Hippies and Libertarians Have Become Unlikely Allies in a War against Solar Power. *Quartz*. https://qz.com/119215/hippies-and-libertarians-have-become-unlikely-allies-in-a-war-against-solar-power/.

Smith, R. 2015. China's Communist-Capitalist Ecological Apocalypse. *Truthout*.

Tabuchi, H. 2017a. Coal Jobs Prove Lucrative, But Not for Those in the Mines. *The New York Times*. https://www.nytimes.com/2017/05/02/climate/coal-jobs-prove-lucrative-but-not-for-those-in-the-mines.html.

Tabuchi, H. 2017b. Rooftop Solar Dims Under Pressure From Utility Lobbyists. *The New York Times*.

Whitehouse, S. 2018. The Koch Brothers & Trump. In: Curwood, S. (Ed.) *Living on Earth*. https://www.loe.org/shows/segments.html?programID=18-P13-00019&segmentID=1.

Zaffos, J. 2016. Can We Learn from Europe's Approach to Laid-Off Coal Miners? *High Country News*. https://www.hcn.org/articles/mining-for-relief-coal-germany-europe-taxes-powder-river.

21

Perspectives on an Energy System After a Decline in Fossil Fuel Use: Welcome to the Store-Age

Andrew Fredrick Crossland

1 Introduction

There are a multitude of routes to a fossil fuel-free energy system, yet all are fraught with challenges and objections. For example, nuclear power provides a low carbon source of energy, but one with high impact risks such that events in Fukushima, Chernobyl and Three Mile Island are ingrained on the human consciousness. Furthermore, issues surrounding nuclear waste storage are a political hot potato meaning many countries still have no future-ready nuclear storage facility (Carrington, 2018). Solar, wind, hydro, and marine power are projected to have a transformative role in displacing fossil fuel use, even though some authors have famously questioned the role they can play in meeting our total energy requirements (MacKay, 2009), in part due to their intermittency but also due to the scale of investment needed. Better efficiency is projected to reduce fossil fuel usage as demonstrated by a switch to low power lighting and improved standards for white goods (European Commission, 2018). Shifting from the internal combustion engine in cars can increase tank to wheel efficiency from less than 40% to more than 90% before air and rolling resistance effects. Similarly, new aircraft designs displacing the role of older, fuel inefficient models (Rutherford, 2016).

As well as shifting away from fossil fuels, there is an increasing desire for power systems to adopt new energy storage technologies. Solar, wind, marine and hydro plants have inflexibilities meaning that their output depends on

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meteorological patterns. The electricity generated by solar panels is directly proportional to the temperature and irradiance of the solar panels or collectors—and that output is extremely unlikely to correlate with the end user requirements for energy. A passing cloud can reduce the output of a large solar plant by more than 90% in a matter of minutes, whilst days of consecutive bad weather are commonplace around the world and affect solar energy output. Wind plants suffer a similar vulnerability, with high output during storms often very quickly followed by low electricity production during so called 'calm after the storm'. The role for energy storage in systems with wind and/or solar as the primary energy source relates in part to the need to provide power when there is no sun and/or no wind and also to mitigate rapid changes in output after a storm, a passing cloud or even a solar eclipse (Rapier, 2017). The output of tidal power stations is similarly constrained by the diurnal patterns of the tides and wave power plants are linked to the conditions of the sea. Some buffers can be built into these plants, such as using tidal barrages across rivers or in dedicated ponds to store water at high tide. This was proposed for the Severn Tidal Barrage to provide a more predictable electricity generation pattern (Neill et al., 2018).

The electricity generated by onshore hydroelectric technologies is in part related to the mechanisms of the rivers. Hydroelectric power stations, which use the flow of water to turn turbines, come in two primary types: run-of-river and barrage. The production of electricity from run-of-river plants will usually be proportional to the flow of the river, that is the volume of water passing through the plant. Barrage systems usually comprise a dam behind which a reservoir of water is allowed to develop. This allows higher power electricity generation and also storage of water to provide a more consistent output whatever the underlying weather, that is the reservoir stores water for weeks or months before it is discharged through the electricity turbines, meaning that the water can be used for power production when needed rather than when the reservoir is being filled or the river is in full flow.

Despite the ability to provide some storage buffers through the containment of water in dams, some hydroelectric plants remain vulnerable to present and future climatic conditions. In New Zealand, a very low snowfall and snow melt in 2018 led to unusually low lake levels. As a result, hydro plants had to reduce their output so much in the October of that year that power prices on the wholesale market increased fourfold (EMI NZ, 2018). In response to falling hydro levels, New Zealand switched on more expensive fossil fuelled power stations, yet unfortunately the fall in hydro levels also coincided with a reduction in production from New Zealand gas production facilities which further pushed up prices. New Zealand has an electricity system with few places to turn to in the event of a very well understood weakness of the nation's hydroelectric facilities—that the water levels in the storage reservoirs will get critically low at least once a decade. New Zealand's electricity depends on a snow melt which is, unfortunately, under threat by the changing climate. It is now being concluded that the country needs storage as part of a mix of solutions to mitigate the impact of weather and climate change on energy security and prices.

For economic and technical reasons, nuclear plants are inflexible so they cannot change their output rapidly or significantly to match our variable demands. This is evidenced by the fact that nuclear plants around the world are used to provide baseload power rather than ramping power up and down to meet peak consumption periods (Loisel et al., 2018). If nuclear power were to play a role as the majority source of power in any electricity system then storage could have a role in providing peak demand, in providing backup if a nuclear power station trips or in providing a source of load if major loads trip. This is in part shown by the building of pumped storage plants in the UK in the 1960s and 1970s to meet peak loads in a system with high amounts of inflexible generation (Torrealba and DNVGL, 2016).

Low cost energy storage is often labelled as the silver bullet to enable a low carbon energy system which meets human energy needs regardless of the weather. There is little debate on whether it has a key role to play alongside other forms of low carbon generation; however, when studying and working with energy storage one really begins to appreciate that much is happening beyond the commonly understood and documented roles for it. Storage is not just beneficial in shifting solar power from day to night or in meeting seasonal electricity demands—it is an enabler of low carbon, distributed energy systems which is allowing homes, communities, businesses and nations all over the world to break their addiction to fossil fuels.

In this chapter, we look at the transformative role that energy storage is having in developing a post fossil fuel world. We see that storage is not just a buffer between the sun and our demand—it is a transformative and disruptive technology that can tackle fundamental issues with fossil fuels, including that:

- Their production is controlled by the few and not the many
- Their use is causing catastrophic changes to the climate
- They support an energy system which is at present not owned by the people who rely on it for commerce, entertainment and, most importantly, survival.

2 Yoga for the Power System

In my twenties, I claimed that I was a yoga teacher. In reality, I had taught one class in the middle of the Namib Desert as a challenge from an expedition leader. However, it is something that gives me a great personal sense of achievement. Yoga also provides a useful anecdote that I frequently use in my personal and professional life. Most people who do yoga will tell you that it is the use of physical stretching combined with meditative techniques to relieve stress and anxiety. In later life, I have learned that yoga has some interesting parallels with an energy system without fossil fuels. In this chapter we see what the concepts of yoga bring to a power systems engineer working on decarbonisation projects around the world.

In 2016, the British electricity system operator, National Grid, released an auction for a new product called enhanced frequency response (EFR). This asked developers to find technology which could provide power to the electricity network in the event of the system frequency rapidly falling. Frequency is the heartbeat of the power system and the rise and fall of frequency shows whether there is a surplus or shortage of electricity at any given time. When the frequency is falling there is usually a shortage of power and when the frequency rises then there is usually a surplus. Reading the frequency is one way that electricity grid operators know how much power to produce to meet demand at any given moment.

The amazing thing about frequency is that it is a near universal value across the electricity network so a meter in the far north of Scotland should almost simultaneously read the same frequency as a meter in London. By reading the frequency of the electricity system in your home you can determine how well it is being managed without having to consult the electricity control room. Although it might be interesting for engineers to follow the frequency of the electricity system, the information is only useful if they have the technology to act. In the event that a major power station fails, frequency can drop sharply, and if no reserve power is brought online then there can be a nationwide or partial blackout (as occurred in parts of Britain in August 2019 after the failure of two gas turbines and then a major windfarm in quick succession). Turning on a power station can take minutes or hours and to avoid a blackout, engineers need backup power to come online fast—life a defibrillator to maintain a heart rate after a cardiac arrest. Historically, some of this backup was provided by large spinning turbines in large power stations, but some of this has been lost with the reduction in the use of coal in the UK.

As more and more inflexible generation facilities are brought onto the electricity network, the ability of system operators to manage the balance of supply and demand falls. This is because wind and solar plants simply do not have the inertia of coal, gas and nuclear plants to keep the system running if there is a frequency event. Without fast backup, drops in frequency happen more often and can be more severe as more variable sources of power are added to the electricity system. As a result, without remedial measures, there is an increased blackout risk in a decarbonised energy system. The EFR tender was designed, in part, to find assets that could quickly and economically provide reserve power. When the auction was complete, it brought results which had repercussions for the global electricity industry.

EFR is a hugely demanding application as it required assets which could increase their output in a fraction of a second—something previously considered expensive with less established technologies. One very new asset class, lithium battery energy storage, was perfectly suited to these requirements. Batteries are well known to be able to provide electricity quickly and reliably, which is exactly why they are used in automobiles to provide the energy needed to start an internal combustion engine. In 2016, there was no other technology that could provide power so rapidly and affordably and, as a result all of the winning bids in the auction were batteries (National Grid, 2016). Overnight, Britain went from having a few trial battery installations to having a large, grid scale energy storage industry. National Grid followed with auctions for the other services that they require in an increasingly decarbonised electricity system; including more frequency products and reserve services. Batteries consistently bid into these auctions and won, showing the role that they have to play in a decarbonised system.

The events of EFR teach a key lesson to all of those who are invested in the electricity system that energy storage is not just useful for the tasks that we all appreciate. Their use in a system without fossil fuels can also extend to allowing the electricity system to flexibly respond to continually changing generation, demand and outages. Yoga helped me relax and de-stress in the Namib desert through helping me become more flexible and now in my role in the power system I use batteries to make it easier to provide low carbon electricity by adding flexibility to power systems.

3 Welcome to the Store-Age: An Introduction to Energy Storage

'Welcome to the store-age' is a phrase which describes well the technologies that could bring about an end to mass fossil fuel use around the globe; from Pacific Islands, to cities and to homes. As a practitioner and researcher in the energy storage space, I am exposed to different perspectives around energy storage which are delivered via social and traditional media outlets. Storage projects certainly capture the imagination of the industry and the public, and many of the journalists involved should be commended for their part in making my field of work seem so exciting! The question of course is whether there is actually a growing energy storage industry ahead of us. In this chapter, I hope to convey my opinion of what storage can do as we say our goodbye to fossil fuels and why this should stimulate a new age in the way energy systems work for us.

Recent advances in electrical energy storage (the storage of electricity as opposed to heat) have undoubtedly been driven by a perceived desire to see the end of fossil fuel generation. Domestic storage products using various types of lithium batteries are specifically designed to work with solar panels on the roofs of houses and reduce the use of higher carbon grid electricity. Hydrogen storage and electrical batteries are being used to offset petroleum and diesel use in the transport sector. Flow batteries are developed to provide long duration and low degradation storage for applications from microgrids to peak power provision.

In recent years, the rapid decline in costs coupled with increased lifetimes have been the key techno-economic triggers to bringing storage into our energy systems. After starting as a practitioner in storage in 2015, the capital cost of batteries fell by 70% in the space of just 12 months. Analysis by Bloomberg New Energy Finance (BNEF) projects that the cost of batteries, in a similar way to that seen with solar photovoltaics, will continue to decline through to 2030 (Chediak, 2018). As a result, BNEFs lithium ion battery price projections are keenly followed and cited by a developing industry.

The rapid cost declines in battery storage are in part as a result of mass production in factories around the world. China, Europe and the USA all have, or have plans for, factories which can produce billions of battery cells a year (Reuters, 2018). These factories increase the scale of production to reduce costs; this mirrors how large reductions in solar module prices were achieved. Industrialists have recognised that battery production must be treated in a similar way to the production of cheap gadgets in order to achieve mass market appeal. The mantra ‘build it and they will come’ is one duly noted by Chinese factories in the battery industry.

Battery manufacturing has been rapidly expanding to provide cells for the growing electric car industry and it is no coincidence that manufacturers of energy storage products are planning or building factories in close proximity to the international automotive industry. Electric vehicle sales are consequently increasing rapidly as a result of the collapsing costs of EV batteries (Hodges, 2018) which make the UK Government announcement of trying to eliminate petrol/diesel vehicles sales by 2040 seem like stating the obvious rather than driving ambitious, health focused policy. In 2018, non-vehicular energy storage sales are mirroring growth rates observed in the inception of the global solar and wind industries. If recent history of these renewable industries is anything to learn from, continued falls in the costs of storage will lead to exponential growth of the battery storage industry.

To further boost the industry, battery lifetime improved dramatically in the second decade of the twenty-first century. As recently as 2010, the major form of battery energy storage were lead acid cells (similar to those used as starter batteries in cars) which could have lifetimes as low as 6 months in solar shifting applications (Crossland et al., 2015). Lead acid batteries have a poor life with rapid degradation and aging which is exasperated by both high temperatures and continued periods of deep discharge. These are particularly problematic for solar power applications where batteries can be left discharged overnight and the obvious correlation between heat and solar power! Just 8 years later, new storage technologies now proliferate including flow batteries, hydrogen and the lithium ion battery family.[1] The rate of improvement of these new storage mediums have caught many by surprise and have increased confidence in the industry. Working in East Africa in the early 2010s, I would frequently hear how lead acid batteries would break easily and be expensive. In contrast, the vast majority of lithium ion battery manufacturers now offer a minimum warranty of 10 years and the degradation of the cells over that time can be as little as 20%. That is in stark contrast to lead cells where degradation could be as much as 50% lost capacity within a fraction of the time. As a sign of what is to come, tests conducted in independent organisations have shown that future batteries could offer lifetimes exceeding thousands of cycles with minimal degradation (ITP Renewables, 2018) which can only increase the appeal.

With flow batteries and hydrogen cells offering better lifetime expectations, coupled with projected cost decreases, the future of energy storage appears to be strong. If these projections are true, then they could change the mix of storage in global energy systems, as is now discussed.

[1] It is vital to remember that there are many different and distinct chemistries which must be judged on individual merits when looking at the future of the battery industry and determining application appropriate technologies.

4 The Changing Energy Storage Mix

One of the remarkable things about switching from a fossil fuel-based energy system to one based on low carbon generation is that under some scenarios we might reduce our global storage reserves rather than increasing them. That might sound like a shocking statement, but one which has some evidence depending on the trajectory taken in decarbonisation.

A fossil fuel-based electricity system inherently comes with large stores of energy. A paper by Dr Grant Wilson in 2010 captures this well by quantifying the energy stored in the gas, oil and coal networks in the UK (Wilson et al., 2010). Coal stacks, gas storage facilities and oil tanks were designed to hold sufficient volumes of fuel to run the British energy system for months at a time. They also allow traders to buy and store fuel when market conditions are favourable whilst also providing a strategic reserve to mitigate against disruptions to supply. In short, these energy storage facilities provide a vital decoupling buffer between when fuels are harvested to when they are used.

In the UK, the goodbye to fossil fuels has included switching off coal power stations—which have transitioned from providing 37% of British electricity generation in 2012, to less than 7% in 2017 (MyGridGB, 2018). However, reducing the number of active coal power stations also reduces the very energy stores (in coal heaps) meaning that Britain is more exposed to changes in the price of gas on international markets. There is no flexibility to procure alternative fuels—namely coal—when the gas price rises. For Britain as a whole, without replacing that coal storage, there are increased risks of supply shortages and higher prices unless investment is made in new energy storage and new low carbon alternatives to gas.

The future electricity generation mix is often the first consideration to observers of the transition from fossil fuels, however of equal importance is finding a future energy storage mix. The makeup of that storage mix is rarely explicitly quantified which is in part due to a lack of agreement about the exact makeup of a future energy system. It is also affected by economics and a capitalist system which uses markets to determine our energy future.

A small case study of the upper end of the energy capacity that Britain might see could provide some answers to what the future storage mix might look like. There are approximately 30 million cars in Britain (Office for National Statistics, 2018) and if all were electric with a battery equivalent to a 200 mile range car (say 140 kWh), the national electrical energy storage capacity in vehicles would be 2.8 TWh. If each of the 26.4 million homes[2] in

[2] See Office for National Statistics (2018).

England, Scotland and Wales (not including Northern Ireland which is on a different electrical system) have a domestic battery storage system (say 15 kWh), these would provide 300 GWh of electrical energy storage. All of the present and proposed pumped storage facilities in Britain (Torrealba and DNVGL, 2016) would provide an additional 100 GWh of storage. If just the storage capacity of cars, homes and pumped hydro were made available to the electricity industry, they would be sufficient to meet present British electricity needs for less than 2.5 days at a time (assuming that people do not mind making their car battery available to the grid!).That is an increase in flexibility for the power system an order of magnitude larger than that available today.

5 Living on an Island: Real Life Examples of Breaking Our Addiction to Fossil Fuels

There are few occasions when my home in a small town near Doncaster can be compared to a tropical island paradise in the Pacific, yet both tell us about and the role that electrical energy storage might play in a post fossil fuel world.

My short career has allowed me to help develop roles for domestic energy storage in the UK as well as solar and battery storage projects around the world. My interest started with a PhD where I examined what small scale batteries could do for utilities in reducing the costs of running electricity networks. My research showed that dispersing batteries in homes and in street-side cabinets could reduce the costs of decarbonising electricity network costs by billions of pounds (Crossland et al., 2018). Moving into industry, I have worked with companies such as IKEA and Nissan to start selling batteries and solar panels to homes across Europe. As a result of both, I was able to examine data from the early adopters of battery storage and measure how much they could save householders, whole nations and everything between.

An oft quoted 'weakness' of solar power is that it can only reduce electricity bills if they produce power at the same time that electricity is being consumed.[3] This is especially true if people are not home during the day when the solar panels are producing electricity. Cutting edge research by (Leicester et al., 2015) found that the occupancy of a house could alter the saving from solar investments from 15% to 69%.

This can be in some way nullified using batteries which help to match solar production to demand. The potential saving from energy storage in a home is

[3] This is not the case in net metering scenarios as in The Netherlands (Poullikkas et al., 2013) or subsidies on generation/export as under the Feed in Tariff (Ofgem, 2016).

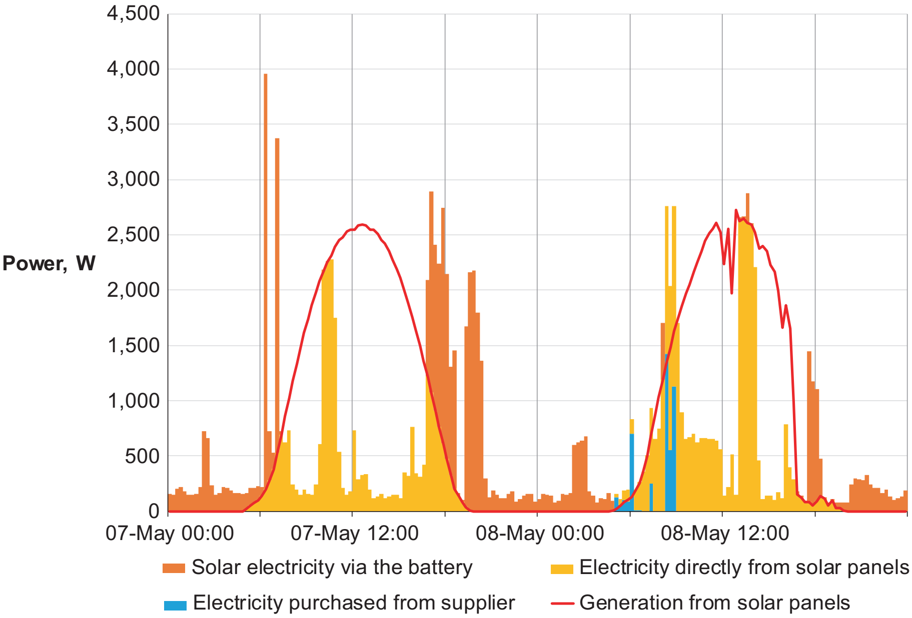

Fig. 21.1 The consumption of electricity of a house with solar and battery energy storage during a summer day. Grid electricity is shown in blue, solar electricity in yellow and electricity consumed via the battery in orange. (Source: © Andrew Crossland (author))

the partial decoupling of appliances, generation and behaviour. Put simply, energy storage can shift solar power from when it is generated to when it is needed meaning that a householder does not need to be home all day or to switch on washing machines when there is an abundance of sunlight in order to gain the greatest benefit from solar. This is demonstrated in Fig. 21.1 showing measured data from a typical solar and storage home in the UK. Here, the storage decouples between when solar power is generated to when it is consumed.

One of the first homes studied during my PhD was my parents' home in Retford in Northern England. Our measurements showed that without batteries, this home used 25% of the solar generated over a year. However, with a battery, the fraction of generated electricity that was consumed in the property increased to 60% per year. As Fig. 21.2 shows, modelling the home with a larger battery and modern solar PV panels using real world data found that the home could achieve the UK 2030 carbon target of 100 g CO_2/kWh through large scale reduction of importing higher carbon electricity from the grid (MyGridGB, 2018).

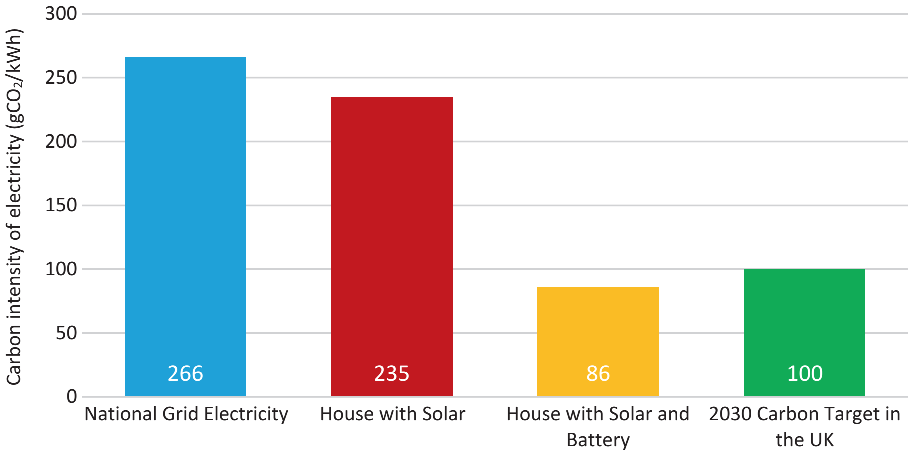

Fig. 21.2 Carbon Intensity of a British home with a large PV array and battery energy storage device. (Source: MyGridGB, 2018. © Andrew Crossland (author))

Solar and storage do not provide all of a home's electricity needs, particularly during winter months where the import of electricity was around 70% of demand in my parents' home. However, storage enables the home to get best use of solar electricity by enabling maximum self-consumption of solar power when the weather is favourable. In Pacific Islands, batteries are also being used to increase the use of solar power when there is good weather and to relegate expensive, imported diesel generators to tertiary sources of energy.

Pacific Island nations have faced a particular issue in their provision of electricity—exasperated by their remoteness and inaccessibility. The nation of Tuvalu comprises three islands and six atolls which support a population of around 10,000 people. These are served by a handful of weekly flights and ships which arrive every three to six weeks (Commonwealth of Nations, 2018). Until the start of the twenty-first century, the island relied predominantly on fossil fuels (via diesel generators) for electricity. The fuel for these generators had to be shipped thousands of miles to the country's main port and then distributed to outlying islands when needed (there is no oil production facilities in Tuvalu). The supply chain for fuel is expensive, long and requires the country to find foreign currency to purchase diesel. All of these factors are recognised in a Tuvalu energy sector development report to be major strains on the economy of the small nation (The World Bank, 2014).

Similar issues are found across the region and many Pacific Island countries are now turning to solar, wind and energy storage to reduce their use of imported fuel. Low carbon alternatives are simply much cheaper than fuel, with paybacks on investment usually significantly less than 4/5 years. They also allow Pacific nations reduce their exposure to turbulent fuel markets and delays in shipping.

In The Cook Islands, my employer (Infratec) have been installing solar power and battery storage systems which have reduced fuel consumption on four islands by 95%. The star performer in these systems is battery energy storage which charges from solar power during the day and then provides electricity at night. Across the region, solar and storage installations are being developed which will provide similar levels of renewable energy to entire countries.

There is still a moderate need for dispatchable electricity generation from generators on most of the islands with renewable energy and storage. On The Cook Islands for example, fossil fuels are used when there is bad weather or when there is a huge increase in demand during festivals. If the batteries are flat or there is insufficient solar power, then an onsite diesel generator is switched on to provide electricity to the islands. In the context of the global energy transition, a 95% reduction of fossil fuel consumption in The Pacific is one of the most powerful case studies that I have seen for what new technology can achieve in the rest of the world. It also brings the levels of fuel use a level which can credibly be met using biofuels, and islands such as Bougainville in Papua New Guinea have famously switched vehicles over to fuel from coconut oil (Mercer, 2007).

The evidence is clear that renewable generation, when tied to electrical energy storage, can have a transformative impact on imported fuels in homes in the UK and in tropical islands. In both cases, storage does not completely remove the need for imported fossil fuels, but it has a substantial impact on carbon emissions and energy independence. As we shall see in the next section, the revolution could have a significant impact on the business models which underpin the whole global energy system.

6 Will Storage Break the Utility Business?

The commercial mechanisms that fund electricity systems in most nations were built at a time where power was generated centrally and transmitted over electricity cables to demand. The only commercially viable way for most homes and businesses to purchase electricity was through the grid and the size of a typical electricity bill will be proportional to the energy consumption. Energy storage fundamentally changes this in a number of ways:

1. As we have seen, when tied with local generation, it allows huge reductions in the use of imported electricity.
2. It allows a user to decouple when they purchase electricity from when the use it, for example a battery can be charged when electricity prices are low and then used when the consumer needs power.
3. It allows users to play an active role in running the electricity system, potentially using their batteries to provide services to the grid as described previously.

These issues are compounded by the fact that utilities are no longer in full control of what is installed on their systems. In the past the entire electricity system from major power stations to transmission lines used to be centrally planned. This contrasts with the future energy system which could have millions of distributed generation and storage assets being installed effectively at random and at scale in homes, businesses, etc.

These effects are so powerful that the model for the way that electricity grids, major power producers and system operators work could fall apart. As a result, large companies heavily invested in the old way of doing energy (such as BP, Shell, DONG and Scottish Power) are now beginning to invest in alternative generation and energy storage (Green Tech Media, 2018; BP Global, 2017; Orsted, 2017).

A good example of the potential changes is the issues faced by lines/distribution companies which have a monopoly on the transport of electricity from power stations to our homes and businesses. These companies own and manage the millions of kilometres of cables and wires that link all of the power stations to where electricity is needed. Every home has one connection to the electricity grid, and that connection is owned, managed and funded by your local distribution company. A householder has no choice but to pay the local distribution company for the cost of providing a connection to the electricity system. In the UK this accounts for 26% of the electricity cost for a domestic customer (Hinson, 2017).

With the advent of viable domestic storage and generation, revenues for the distribution companies could fall by up to 75% from some homes. At the same time, network companies will almost certainly have to invest in more cables and wires to enable electric cars and heat. There is a wealth of academic and practical evidence that distributed storage can reduce the cost of upgrading networks to provide future electricity needs (Strbac et al., 2017). However, most of these models require, at some level, some participation in network operation from behind the meter storage—a level of participation which must be incentivised. This changes distribution companies from organisations that used to manage cables and transformers to ones which need to work out how to actively engage with their customers in a way they have never done before.

Another good example of the transformative effect that storage has on the way that energy systems are funded can be seen by looking at the cash flows involved. For example, storage, solar, and wind have low running costs in comparison to fossil fuel plant; however, there is a high upfront cost in building these new systems. The high upfront cost can be equated to asking an investor, utility or developer to purchase up to 30 years of electricity generation upfront. This is at odds with an energy generation system which relies on regular payments for fuel and electricity as fuel is slowly burned.

In order to encourage investment in a high capital energy system, it is important to have confidence in the long-term revenue streams as the more certain the revenue then the less risky investment is perceived. Private utilities might not be prepared to take this risk—or will place a much higher financing cost on a project, unless the revenue streams are certain—and this is in part why government schemes to fund or back energy investments can be so successful in driving down costs. Quite simply, correctly designed government backed schemes have been shown to be more bankable than wholesale energy markets in some cases, as was the case with the UK contracts for difference helping to bring down the cost of offshore wind generation.

The requirement for high capital does not just affect energy investors, it also affects consumers who are being asked to find thousands or millions of pounds to fund their own energy projects. As a result of this, those least willing/able to find large sums of cash are being left out. This in itself is a major barrier to developing a low carbon energy system which requires mass adoption of new technology across most homes and businesses.

The commercial models which fund energy for business and householders are having to adapt. The most successful energy projects are often where the financial element is given equal recognition as the technical and social elements, that is, the unique financial and social implications of high capital low fuel energy technologies must be considered by utilities and governments from the start as much as the well understood technical challenges. The players which make a success of the end of fossil fuels will be those that are truly interdisciplinary.

7 Mind the Policy Gap

At the time of writing, there have been huge advances in battery energy storage technology which have enabled electric vehicles and behind the meter battery storage projects. It seems likely the recent falls in costs and improvements in technology will lead to mass adoption of batteries in cars and possibly homes in the coming decades. However, there remain some key barriers to storage which are important to overcome to accelerate the decline of fossil fuel generation. A few of these are now presented.

The first gap is an area where there seems to be no widely accepted technology option at the time of writing—the issue of providing storage capable of providing long distance transportation. Air travel and shipping are large users of fossil fuels. Aviation fuel is energy dense allowing planes to travel long distances without refuelling and there seems to be no technology yet able provide high density storage for this sector. Some early forays and trial projects are underway, but this sector needs particular research attention due to the carbon and local air pollution impacts of the industry (MacKay, 2009).

Another technological gap often overlooked is the storage of heat. The energy demand of domestic heat is much larger than the total national electricity consumption during British winters (Fig. 21.3), and that heat is predominantly provided using natural gas. Decarbonisation needs improvements in efficiency of heating through better insulation, alternative heat production mechanisms and also needs heat storage to act as buffers between energy

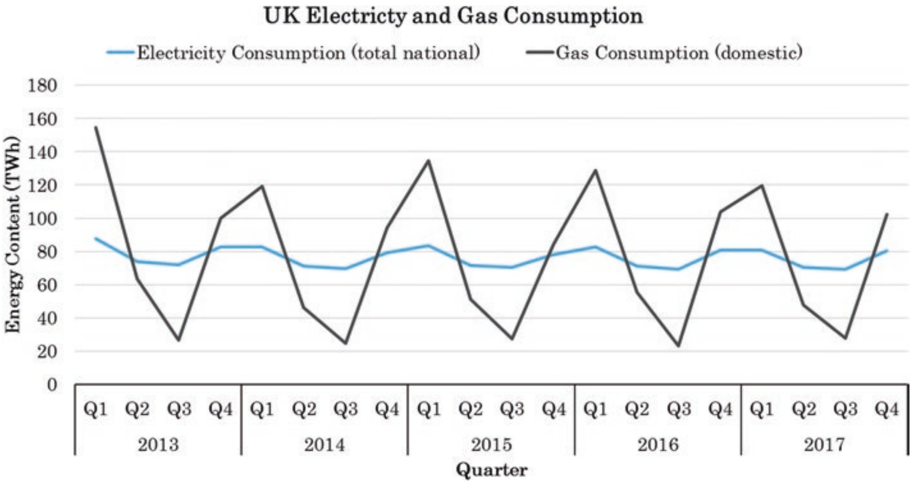

Fig. 21.3 UK national electricity consumption and domestic gas consumption. (Source: Department for Business, Energy and Industrial Strategy (BEIS, 2018a, 2018b))

production and consumption (see Chap. 22 on decarbonising heat). As a corollary to the requirements for decarbonising electricity, it is thought that effective and commercially viable low carbon heat and heat storage will be important in removing fossil fuel from the heat sector.

Beyond these technological challenges, shifting from fossil fuels threatens millions of global jobs and large national economies. The discovery of oil in a country can be seen as a huge boom for economy and development and for these to transition away from fossil fuels requires a credible economic alternative which creates jobs and stimulates development. Without doing so, there will always be resistance to the transition. Failure to recognise the economic impacts of the fossil fuel transition could leave millions destitute or impoverished. If the energy transition is done correctly then it should and could support sustainable jobs and skilled local economies as well as protecting the environment. With the collapse of the coal mining industry, the UK has already seen what poorly planned changes to the energy system can mean for local jobs and prospects. The energy storage industry might be a means for some economies to create jobs and circular economies. For example, if a means of mass energy dense storage were found then nations could produce energy and ship it to other parts of the world, much like the fossil fuel industry does today. That might seem a far-fetched idea, but if high density energy storage technologies are found they will open up new opportunities for business and trade in ways which are beyond the imagination of present society.

The final challenge is to properly recognise the interdisciplinary nature of energy storage in a fossil fuel free world. Storage, particularly decentralised storage, poses a huge threat to the existing technological and commercial structure of the energy industry. As such, ownership of energy could be restored to thousands rather than hundreds of participants. The implications for engineers are probably solvable, for example by using standards to drive how storage should behave. For example, it is my personal view that standards agencies should evaluate whether behind-the-meter storage should have an inbuilt power system support capability defined in the grid codes of each electrical system. I am personally suspicious whether it is cost efficient to pay for large storage facilities to provide all of the grid balancing functions when some of this can be introduced through small distributed batteries. Grid codes are an ideal way to enforce preferable behaviour on distributed technologies as is already done on some distributed generators.

Similar to the way decarbonised energy needs credible and robust long-term revenue guarantees to encourage investment, storage has similar needs to stimulate an industry and accelerate the transition from fossil fuels. The National Grid EFR auction and UK Government Contracts for Difference have proven what strong financial mechanisms can do to encourage technology innovation and cost reduction. That has to continue to keep the storage industry strong and markets can be a good way to bring the right amount of flexibility to the electricity system.

8 Conclusion

In this chapter we have seen that energy storage should have a wide role in supporting the transition away from fossil fuels. Storage supports renewable generators, electricity networks, nuclear power stations, remote communities and even homes in Northern England in leading the way towards decarbonisation. Storage provides flexibility beyond that presently available to today's power system engineers. That should be a key benefit in helping the electricity system flex demand to better meet generation such as consuming power on sunny days to make the best use of solar whilst also providing backup to large power stations. The viability of the future of energy storage depends on continued improvements in storage costs, life, quality and material sustainability. This viability should lead to growth in everything from houses through to electric cars and from Doncaster to Fiji. Continued innovation is likely to lead to a range of technologies including pumped storage, biomass stores and flow batteries and not just various lithium batteries.

The opportunity that storage presents to the electricity industry is huge, and one which presents lessons to other decarbonising energy sectors such as heat and transport which present even more fossil fuel addiction than power. Encouragingly, energy storage is already widely recognised as part of the 'long goodbye' to fossil fuels yet to enable it requires the right policy, economic incentives and technological innovations. To make that happen is a role for industry, society and potentially government and doing so is a challenge that I am relishing. Welcome to the store-age and let's slowly wave goodbye to fossil fuels.

References

BP Global. 2017. *Lightsource and BP Join Forces to Drive Growth in Solar Power Development Worldwide. Press Releases Media BP*. https://www.bp.com/en/global/corporate/media/press-releases/bp-alternative-energy-announcement-december-2017.html.

Carrington, D. 2018. Allow Nuclear Waste Disposal Under National Parks, Say MPs. *The Guardian*. https://www.theguardian.com/environment/2018/jul/31/allow-nuclear-waste-disposal-in-national-parks-say-mps.

Chediak, M. 2018. The Battery will Kill Fossil Fuels—It's Only a Matter of Time. *Bloomberg*. [Online] https://www.bloomberg.com/news/articles/2018-03-08/the-battery-will-kill-fossil-fuels-it-s-only-a-matter-of-time.

Commonwealth of Nations. 2018. *Find Freight, Shipping and Logistics Expertise in Tuvalu*. http://www.commonwealthofnations.org/sectors-tuvalu/business/freight_shipping__logistics/.

Crossland, A.F., Anuta, O.H. and Wade, N.S. 2015. A Socio-technical Approach to Increasing the Battery Lifetime of Off-Grid Photovoltaic Systems Applied to a Case Study in Rwanda. *Renewable Energy* 83: 30–40.

Crossland, A.F., Jones, D., Wade, N.S. and Walker, S.L. 2018. Comparison of the Location and Rating of Energy Storage for Renewables Integration in Residential Low Voltage Networks with Overvoltage Constraints. *Energies* 11(8): 2041. https://doi.org/10.3390/en11082041.

Department for Business, Energy and Industrial Strategy (BEIS). 2018a. *Natural Gas Supply and Consumption*, 20 December 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766376/ET_5.2.xls.

Department for Business, Energy and Industrial Strategy (BEIS). 2018b. *Supply and Consumption of Electricity*, 20 December 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766369/ET_4.1.xls.

EMI NZ. 2018. *Wholesale Energy Prices*. https://www.emi.ea.govt.nz/Wholesale/Reports/W_P_C?DateFrom=20180101&DateTo=20181231&RegionType=NZ&TimeScale=DAY&WeightedBy=DEMAND&_cy0=20170101&_cy1=20160101&_cy2=20150101&_cy3=20140101&_si=fr|1025,frc|D,v|2&seriesFilter=NZ.

European Commission. 2018. *Energy Efficiency—European Commission*. https://ec.europa.eu/energy/en/topics/energy-efficiency.

Green Tech Media. 2018. *Sonnen Raises $71M and Kicks Off a Strategic Partnership with Shell | Greentech Media*. https://www.greentechmedia.com/articles/read/sonnen-raises-71m-and-partnership-with-shell.

Hinson, S. 2017. *Energy Bills and Proposals for Reform Contents: 1. Background 2. Reform of the Energy Market 3. A Price Cap 2 Domestic Energy Bills*. London: s.n.

Hodges, J. 2018. *Electric Car Costs Set to Fall*. https://www.bloomberg.com/news/articles/2018-03-22/electric-car-costs-set-to-fall.

ITP Renewables. 2018. *Battery Test Centre Report 4*. Canberra: s.n.

Leicester, P., Goodier, C. and Rowley, P. 2015. *Evaluating Self-Consumption for Domestic Solar PV: Simulation Using Highly Resolved Generation and Demand Data for Varying Occupant Archetypes*. Proceedings of 2015 11th Photovoltaic Science, Applications and Technology Conference (PVSAT-11), Leeds.

Loisel, R., Alexeeva, V., Zucker, A. and Shropshire, D. 2018. Load-Following with Nuclear Power: Market Effects and Welfare Implications. *Progress in Nuclear Energy* 109: 280–292.

MacKay, D.J.C. 2009. *Sustainable Energy—Without the Hot Air*. s.l.: UIT.

Mercer, P. 2007. *BBC NEWS Asia-Pacific: Coconut Oil Powers Island's Cars*. http://news.bbc.co.uk/2/hi/asia-pacific/6634221.stm.

MyGridGB. 2018. *MyGridGB*. http://www.mygridgb.co.uk.

National Grid. 2016. *Enhanced Frequency Response Market Information Report*. Warwick: s.n.

Neill, S.P. et al. 2018. Tidal Range Energy Resource and Optimization—Past Perspectives and Future Challenges. *Renewable Energy*, 127: 763–778.

Office for National Statistics. 2018. *Total Number of Households by Region and Country of the UK, 1996 to 2017—Office for National Statistics*. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/adhocs/005374totalnumberofhouseholdsbyregionandcountryoftheuk1996to2015.

Ofgem. 2016. *Feed-in Tariff About the Scheme and How to Apply*. London: s.n.

Orsted. 2017. *DONG Energy to Change Company Name to Ørsted*. https://orsted.com/en/Company-Announcement-List/2017/10/1623554.

Poullikkas, A., Kourtis, G. and Hadjipaschalis, I. 2013. A Review of Net Metering Mechanism for Electricity Renewable Energy Sources. *International Journal of Energy and Environment* 4(6): 975–1002.

Rapier, R. 2017. *How The Solar Eclipse Will Impact California Utilities*. https://www.forbes.com/sites/rrapier/2017/08/17/how-the-solar-eclipse-will-impact-california-utilities/#74c3363d1402.

Reuters. 2018. *Factbox: Plans for Electric Car Battery Production in Europe | Reuters*. https://www.reuters.com/article/us-autos-batteries-europe-factbox/factbox-plans-for-electric-car-battery-production-in-europe-idUSKCN1J10N8.

Rutherford, D. 2016. *Size Matters for Aircraft Fuel Efficiency. Just Not in the Way That You Think*. https://www.theicct.org/blog/staff/size-matters-for-aircraft-fuel-efficiency.

Strbac, G., Aunedi, M., Konstantelos, I., Moreira, R., Teng, F., Moreno, R., Pudjianto, D., Laguna, A. and Papadopoulos, P. 2017. Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems. *IEEE Power and Energy Magazine* 15: 32–41. https://doi.org/10.1109/MPE.2017.2708858.

The World Bank. 2014. *Tuvalu—Energy Sector Development Project*. s.l.: s.n.

Torrealba, P.J.R. and DNVGL. 2016. *The Benefits of Pumped Storage Hydro to the UK*. London: DNVGL.

Wilson, I.A.G., McGregor, P.G. and Hall, P.J. 2010. Energy Storage in the UK Electrical Network: Estimation of the Scale and Review of Technology Options. *Energy Policy* 38(8): 4099–4106.

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Decarbonising Heat in Scotland: The Perfect Storm Revisited

Keith Baker

1 Introduction

From the first flickers of civilisation humans have had an innate desire for warmth. From the campfires of early hunter-gatherers through Roman hypocausts and the grand fires that both heated and fed mediaeval banquets, to the myriad of ways we generate heat today, the ways we have devised to stay warm both reflect and underpin our societies, cultures and traditions. Yet now, in the face of climate change and growing social inequality, we stand at a crossroads from which we must choose a path that will lead us to decarbonising our heat supplies whilst also enabling more of us to heat (and cool) our homes to comfortable levels. This will require not just ramping up renewable energy capacity, but also strategic planning to realise the wider benefits of installing and upgrading infrastructure and, critically, capturing and recycling the vast amounts of heat we waste every day.

Decarbonising heat supplies and recovering waste heat from infrastructure are two closely intertwined problems. Many of us rely on infrastructure to provide us with heat and yet that infrastructure is incredibly wasteful with this resource, from centralised power plants that dump waste heat into waterways and the atmosphere, to the pipes carrying warm water away from our homes. In our previous book I argued that there would be a public outcry if we could

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see waste heat piling up in landfill sites (Baker, 2017) and yet, compared to other aspects of decarbonising energy, progress on recovering waste heat and decarbonising heat supplies has been painfully slow. Furthermore, here in Scotland competing priorities for decarbonising the economy mean heat stands to lose out at a time when the need for strategic thinking and investment in infrastructure has never been greater, resulting in a very real risk of a perfect storm arising in the mid-2020s.

This chapter draws on recent experience from Scotland, which has embarked upon an ambitious political programme to reduce its greenhouse gas emissions by 80% by 2050 (against a 1990–1995 baseline) (Scottish Government, 2009) whilst also addressing a range of related societal needs including tackling fuel poverty, enabling community empowerment, and regenerating deprived rural and island communities. It explores the range of options that could be deployed in Scotland, what is needed to enable them, and why progress to date is lagging far behind what is needed. Finally, it returns to the question of how real the risk of that perfect storm now is, and why it may be more real now than ever.

2 Decarbonising Heat in Scotland

In Scotland, the government's plans for decarbonising heat under the Scottish Energy Strategy (SES) centre around a combination of shifting households to renewable electric heating and developing low and zero carbon district heating systems (DHS) (Scottish Government, 2017a, b, c), with a target of meeting 11% of heat demand by 2020 (Scottish Government, 2011). However, I will argue, progress is being hamstrung by a lack of strategic thinking and a political desire not to 'pick winners'. Yet competitive contracting for DHS and related infrastructure projects, such as for the pathfinder projects being funded under Scotland's Energy Efficiency Programme (SEEP) (Scottish Government, 2016a) is an incredibly wasteful process that is tackling the problem the wrong way around. Furthermore, whilst First Minister Nicola Sturgeon has confirmed that the Scottish Government's intends to establish a publicly-owned not-for-profit energy company by the end of the current Parliament (Scottish Government, 2018), the current proposals are lacking in detail and also fail to address the need for strategic planning (Baker et al., 2019).

This disconnect in political thinking is built not just on a belief in competition, privatisation, and market-led solutions (and the devolutionary limitations under which the government operates), but also on a poor evidence base that fails to account for how cultures, traditions, and societal norms shape the decisions we make about energy and the needs of householders. For example, the Scottish Government understands the indirect benefits (co-benefits) that can be unlocked linking up the development of DHS with locally sourced, sustainable, biomass production to create local employment, provide recreation tourism opportunities, and enhance biodiversity (Pridmore et al., 2017); but it steps back from using its own data to target resources to areas where such projects would be most appropriate and have the greatest benefits (Baker et al., 2019).

This places the onus on those competing for funding to spend their own resources on gathering evidence on these themselves, and invariably leads to decisions being based on limited and abstracted evidence. This, in part, also reflects another problem with Scottish policymaking discussed in the previous book, the persisting belief in the validity of using modelled data, proxies, and assumptions in place of easily available real data. In the case of alleviating fuel poverty this means that the extent of the problem in deprived rural and island areas is being insufficiently captured by national statistics, which in turn serves to weaken the case for targeting support for developing renewable heating to some of the poorest and most isolated households in the country (Atterson et al., 2018; Baker et al., 2016, 2018;; Mould and Baker, 2017; Mould et al., 2014).

Yet another problem implicit in Scottish policymaking is that, in seeking to emulate the successes seen in countries such as Denmark and Germany, the Scottish Government is overlooking the evidence for how these have been underpinned and shaped by their different political and cultural histories and traditions (Morris and Jungjohann, 2017). One example of this, that relates to the belief in markets, has been resisting calls for a Heat Planning Law to leverage the co-location of housing and non-domestic buildings with new and existing heat sources, even though this has been central to the often-cited success of the deployment of DHS in Denmark (Baker, 2017; Baker et al., 2012; Emmanuel and Baker, 2012; Mould, 2018).

Furthermore, capturing waste heat and DHS are far from the only opportunities the Scottish Energy Strategy fails to grasp. The potential of solar thermal and domestic ground-source heat pumps (GSHPs) for providing low cost renewable heating (Andreadis et al., 2013; Baker et al., 2012; Clarke et al., 2008) remains woefully under-utilised, the development of anaerobic digestion in rural areas remains sluggish despite the potential financial returns (NNFCC, 2017); proposals to capture heat from flooded mineworkings and develop deep geothermal show huge potential but also high costs and high site-specificity (Church et al., 2013; Scottish Government, 2013a); the potential for air source heat pumps (ASHPs) has been over-estimated (Baker, 2017; Scottish Government, 2013b); and the development of policy is failing to keep pace with advances in high efficiency electric heating, storage and smart grids (Atterson et al., 2018). All of these technologies, and more, will no doubt have roles to play in Scotland's energy future, but deploying them effectively requires a level of strategic planning that has so far been largely absent from political thinking.

3 Risks and Barriers to Decarbonising Heat

Comparing Scotland's slow progress on decarbonising heat to its rapid deployment of renewable electricity generation technologies begs the question of why such a gulf exists between achieving these goals. In 2011 the Scottish Government set itself the target of achieving 100% of electricity demand from renewables by 2020 and an interim target of 50% by 2015 (Scottish Government, 2011), and then confounded its critics by exceeding the interim target. Unsurprisingly, this means that much of the proposals for renewable electricity generation under the SES amount to 'more of the same'— unless further devolution of powers is secured the country will carry on with more of what it's been good at so far and focus heavily on developing new on and offshore wind farms and other forms of centralised renewable energy.

As such, the chances of meeting 11% of heat demand and look far from certain. Renewable heat met 4.8% of demand for 2016, and the rate of increase between 2016 and 2020 will need to exceed the current trend. However, the elephant in the room here is that the projections for renewable energy demand for decarbonising transport show an even greater increase will be needed (Scottish Government, 2017d). Unless this changes significantly in the next few years, we can expect increasing competition for resources and support for meeting these three targets, and if the past is any indicator of the future it'll be heat that will lose out.

Decarbonising transport under the SES means a mix of more renewable energy for electric vehicles (EVs) in urban areas and the central belt, and using hydrogen in rural and island areas. This is a perfectly sensible approach for the country and one on which there is a good degree of consensus. However, the rate of increase in supply and demand needed to meet the target of 10% of transport to be powered by renewables by 2020 means the rate of increase in renewable electricity generation capacity will need to outpace the collective increases in demand from transport and electric heating and cooling. Furthermore, the hundreds of thousands of EVs expected to be on the road long before the end of the next decade will not only change the national demand profile, but also result in different demand profiles at very local levels, and so will require both grid reinforcement and more localised supply and demand management (Atterson et al., 2018). The long-term planning and investment needed to mitigate the risks posed by these factors should've been in place years ago, but the risks remain unaddressed by the Scottish Government and, as I predicted in the previous book, this could be the genesis of a perfect storm in the early to mid-2020s. The latest figures do nothing to allay these concerns, and the lack of political progress only strengthens them.

Here lies another barrier to decarbonising heat. The deployment of EVs may currently be limited, but it is something else policy makers know how to do, and the market is already on board with the plans. This is in no small part due to the widespread adoption of electric vehicles by local authorities and public services, as well as development by private investors such as Ecotricity (Ecotricity, 2018), meaning Scotland already has a large and growing network of charging points (EVAS, 2018). More still needs to be done to push these into rural and island areas, but the basic infrastructure is there and these areas are where hydrogen is expected to play a significant role, particularly due to the distances between settlements. Hydrogen may be a newer technology for policy makers to adapt to, but as part of the wider development of energy storage technologies in the highlands and islands it is benefitting from significant public and private investment (REA, 2016).

So why are we seeing this divergence? A cynic would suggest that heat simply isn't sexy compared to compared to media-friendly Tesla sports cars and high-tech energy parks, and it would be hard to argue that there isn't at least a grain of truth there. It would also be easy to point to the markets, as even the more aesthetically pleasing and cost-effective option of solar thermal has struggled to gain traction amongst Scottish householders, despite not being limited by grid constraints. Similarly, the market for domestic ground and air source heat pumps (GSHPs and ASHPs) has so far failed to take off, with the combined contributions of solar thermal and heat pumps meeting just 11% of renewable and low carbon heat capacity in 2016 (EST, 2017).

Yet another small-scale option available to householders able to afford the investment are domestic biomass boilers and combined heat and power (CHP) systems, but whilst these are growing in capacity in rural and island areas (and aside from the very real concerns about the sustainability of fuel supplies) the density of Scottish towns and cities and the 'canyoning' effects created by long rows of tenements means these are tightly regulated in urban areas (SEPA, 2010). Therefore, at a domestic scale it can be argued that there may be room for market-based solutions backed with regulatory incentives to boost renewable heat generation, but it is at the community scale that it becomes clear when the Scottish Government's approach cannot deliver effective, or indeed equitable, solutions to decarbonising heat.

To illustrate this let us take the example of a technology that has so far yet to feature in this discussion. Energy from waste plants provide a means for generating cheap, low(er) carbon heat, particularly in urban areas with dense concentrations of demand. Yet they are notoriously unpopular in the UK, and often with good reason (Upham and Shackley, 2007), and this is reflected in the signs that the growth in the industry in Scotland appears to be largely driven by rural and agricultural applications (including anaerobic digestion) although the official figures lack sufficient granularity to state this conclusively. Energy from waste contributed a mere 5% to renewable heat capacity in 2016, over 80% of which was from 'advanced conversion technologies' (including anaerobic digestion CHP and heat as well as biomethane to grid technologies) (EST, 2017), and as six of the Scottish plants are listed as using municipal waste, whilst five are listed as using biomass (SEPA, 2018) it seems safe to assume that the future for municipal waste to energy will remain limited. However, whilst the Scottish Government and local authorities have largely resisted the temptation to impose the cheap but unequitable solution of energy from waste on poorer communities, they are also struggling to develop the far more equitable solution of developing district heating powered by sustainable biomass and renewables.

The Scottish Government has set itself the target of delivering 1.5 TWh of heat demand from district or 'communal' heating (Scottish Government, 2016b), yet differences in how data has been gathered and statistics are reported (e.g. by household connections, specific fuel types, etc.) and incomplete data mean that in practice it is currently difficult to accurately gauge progress against this target (EST, 2017; Ofgem, 2015). Here again, a cynic would suggest one reason for this is that policymakers are concerned that the national picture is not an optimistic one. It's far easier for them to point to specific examples of operational systems in places such as Lerwick (Shetland) (Siemens, 2011), Aberdeen (Aberdeen City Council, 2017), Calside (Renfrewshire) (CarbonPlan, 2018), Edinburgh (City of Edinburgh Council, 2015), and Glasgow, where the public profile of DHS was raised by its incorporation in the design of the athletes' village for the 2014 Commonwealth Games (Euroheat and Power, 2016); and essentially leave it to industry and local authorities to come up with new projects and compete for funding. All of this serves to obfuscate the detail of what is, and isn't, actually happening.

As I commented in the previous book, following Scottish Government policy on heat means following a seemingly endless trail of documents and proposals that are full of aspiration but largely devoid of detail, and 2017 provided a classic example of this in the shape of not one but two consultations on the Local Home Energy Efficiency Strategy (LHEES) (Scottish Government, 2017b, c), which is the main (but not only) policy vehicle for DHS deployment. Now, you might think that the Scottish Government, having issued a woefully poor first consultation that was completely lacking in an understanding of the real world of deploying DHS and the need for (and benefits of) long-term strategic planning, and having received what might politely be termed 'significant pushback' from local authorities and other stakeholders, would recognise it had dug itself a hole and the strategy needed a re-think and a lot more technical detail. But no, it kept digging, and the second consultation not only managed to repeat much of the first, but to actually be worse in terms of the level of detail it contained; and let's not forget the many hours stakeholders have had to plough into preparing their responses to two consultations which appear to have been written in less time. To say at present, and at least in private, that the attitudes of the local authorities and others who will actually have to do the groundwork to deploy new DHS schemes under LHEES are not exactly positive would be a massive understatement.

So how did things get this bad? One reason, but arguably the most important, is that policymakers have failed to learn that you cannot look at the deployment of DHS and other heat decarbonisation technologies in other countries, or indeed in different regions of Scotland, and simply say 'do that, over here, now' (Morris and Jungjohann, 2017). The next section explores what can and, critically, cannot be learned from the successes elsewhere that the Scottish Government is seeking to emulate.

4 Learning from Others?

Policy makers frequently look to learn from successes elsewhere in the world but often fail to grasp the different contexts that have made them possible or held back progress in other countries. This section summarises progress on the deployment of low and zero carbon heat technologies in a selection of countries most comparable to Scotland, and considers what has, and hasn't, been learned from them.

Of all the Scottish Government's failures on developing renewable heat supplies the low deployed capacity of solar thermal is easily the most depressing. Contrary to popular belief, it even has a role in the far north of the country, which on average receives around two thirds of the solar irradiation as the south of England, and as a heating solution it generally outperforms competing technologies (e.g. heat pumps) across a range of environmental, social and economic factors (Greening and Azapagic, 2014). It also has significant potential for alleviating fuel poverty (Andreadis et al., 2013). Yet despite this it amounts to a mere 2% (19 GWh) of installed renewable heat capacity, all of which are small installations (EST, 2017). Contrasting this to development in other northern European countries is an easy way of seeing quite how far Scotland is lagging behind.

Despite its northern latitude and reliance on abundant sources of hydropower even Norway is now making significant investments in solar thermal. In 2011 the estimated capacity was a mere 13 MWh (Mauthner et al., 2014) however, in 2012 the development of a large installation to supply the Lillestrøm district heating system added 4 GWh to capacity (IET, 2012), in a combined technology approach that has yet to be applied in Scotland despite its renewed focus on developing district heating.

Denmark, which also benefits from significant renewable electricity capacity, is following a similar trajectory with the development of solar thermal district heating at sites including the nine largest solar thermal plants in Europe. These include Dronninglund (26MW_{th}) (PlanEnergi and Niras, 2015), Marstal on the island of Aeroe (23MW_{th}) (GSTE, 2014a), and 13 MW_{th} installations at Grasten and Braedstrup. However, Denmark is going further by combining these plants with the often-overlooked potential of using water stored in boreholes (e.g. at Braestrup) and gravel-lined pits (e.g. at Dronninglund and Marstal) to provide inter-seasonal thermal storage (Stadler, 2014).

In Sweden, the solar thermal market is actually in decline, the country having switched largely to biomass-fuelled district heating in urban areas and heat pumps in rural areas, and smaller installations also compete with solar photovoltaics, which also benefit from stronger financial incentives (GSTE, 2014b). And finally, in France, another country commonly compared to Scotland due to their distinct urban-rural divides, the energy transition law passed in 2015 (French Government, 2018) is serving to drive rooftop installations away from solar thermal and towards solar photovoltaics (and green roofs) however, the legislation has also made new subsidies available for large DHS-connected solar thermal arrays, with the first of six new installations becoming operational in late 2017 (GSTE, 2014c).

Of course, solar thermal cannot decarbonise DHS heat supplies in isolation, and whilst gas remains a common fuel for matching with it, northern Europe has seen a rapid and significant growth in using biomass. However, under current conditions replicating this shift in Scotland would raise significant concerns over the sustainability of the biomass fuel supply. The risks around using imported supplies are covered in our previous book (Baker, 2017), and despite having set a target of reforesting 21% of Scotland by 2032 progress is running far behind the rate need to achieve this—the afforestation rate is currently 4,800 hectares per year and needs to reach 15,000 hectares per year by 2024 (Forestry Commission, 2017; SNH, 2017). Anaerobic digestion can be used to support this demand however, the wider benefits (co-benefits) of developing local, sustainable biomass fuel sources that are also managed for construction products, recreation, tourism, and biodiversity would be significant, and would have the additional benefit of providing employment and supporting regeneration in many deprived areas, and those where the decline of the fossil fuel industry will lead to job losses (Pridmore et al., 2017).

However, those supplies will require a demand, and Scotland, and the UK in general, has had a mixed history of developing district heating systems. The vast majority (~85%) of the UKs systems were constructed before 1990, with many built to heat homes in the cheap new residential estates and blocks of flats constructed to house the post-war baby boomers. This association with undesirable poor-quality housing is one factor that may explain its decline in popularity until the 2000s, after which the UK has seen a renewed interest in the technology, with 30% of the UK's large installations built after the turn of the century (DECC, 2013). As a result, public awareness is very low, with a recent government study reporting this sitting at around 17%. However, perhaps reflecting a younger and more energy aware generation, almost half of those aware of DHS view it positively, and over half of them would be likely or very likely to connect to a system (DBEIS, 2017).

This lack of social and cultural awareness is a problem for DHS that policy makers appear to be overlooking whilst seeking to emulate progress elsewhere. Denmark is frequently held up as an example to follow, but the Danish success is the result of well over a century of investment and a culture of public and community ownership. Copenhagen is a global hotspot for DHS, with twenty-one municipal and community owned networks reaching staggering 98% of the city's buildings—providing around 8,500 GWh of heating for 75 million square metres of floor area at an average carbon cost of 100 $kgCO_2$/MWh. But that success began as far back as 1903, and in 1984 saw an investment of €379 million in a new pipe network, with cooling infrastructure being added from 2010 (DBEIS, 2018). Denmark is also pioneering using wind power, heat storage, and heat pumps to fully decarbonise its district heating systems. This is not the sort of progress that can be achieved overnight, or indeed within the coming decade.

Similarly, another frequently cited example of best practice in urban heat networks, the redevelopment of Hammarby Sjöstad in Stockholm, Sweden, has benefitted significantly from a similar culture of ownership by and for the public good, and a design approach that has waste recovery at its very heart, to the extent of recovering heat from waste water (Envac, 2017; Gaffney et al., 2017).

In contrast, Germany another world leader in decarbonising energy and being one of the largest EU markets for DHS in absolute terms (along with Poland), development has been much more limited, with DHS having a market share of only 13.8% of domestic properties as of 2015. Much of this development has been in Berlin, Munich, and Flensburg and, notably, 47% of the energy is generated from burning coal (Euroheat and Power, 2017a). The development of DHS in Poland and other post-Communist central and eastern European countries, where it has traditionally been more common, also suffers from aging infrastructure and a reliance on coal (SIE, 2012).

In Norway, as of 2015 DHS systems still accounted for only around 12% of heating and cooling demand, much of which being for back up energy supplies in the larger cities (Euroheat and Power, 2017b). However, as previously noted, Norway is also moving towards solar-thermal combinations with conventional DHS and has significant potential to combine these with the passive storage solutions being pioneered in Denmark. Notwithstanding the untapped potential of domestic solar thermal and building-integrated heat storage (Arteconia et al., 2013), it is passive thermal storage and the Swedish use of heat recovery technologies that are the final pieces in the puzzle of making DHS a viable and cost-effective solution to decarbonising heat.

However, these examples also demonstrate the dangers of assuming a rapid rollout of DHS in Scotland is possible without understanding the historical and cultural influences on developing and decarbonising heat supplies. It may ultimately be possible to emulate Denmark if political attitudes towards centralised planning were to change, but the social and cultural changes needed to raise and normalise positive public attitudes are still likely to take decades to bed in, and both the political and financial investment needed would be highly significant. The successful deployment of DHS will also require a holistic and long-term policy approach that includes the whole supply chain and takes into account the co-benefits of developing sustainable, local fuel supplies. Such developments would be entirely in keeping with Scottish culture but, here again, the question is whether the Scottish Government will realise that one of the biggest cultural barriers to DHS is its own culture of not picking winners.

Now it would be easy to wrap up this chapter with a summary of the size of the hole the Scottish Government has now dug itself, but that would be no better a use of words than the second LHEES consultation. So, let us take a step forward and consider what a truly aspirational Scottish solution to decarbonising heat might actually look like, using the example of a cornerstone of Scottish architectural culture and tradition.

5 Learning From the Past?

My favourite carbon factoid comes from a presentation given at the Initiative for Carbon Accounting's 5th international conference by Professor Angela Druckman of the University of Surrey (Druckman, 2013). Professor Druckman asked the audience which aspect of the lifecycle of a toilet bears the highest carbon cost, to which the answer is the heat lost when the warm waste water is flushed down into cold sewers. It is one of those facts that seems really obvious once you make the connections, and it neatly illustrates the need for holistic, whole systems approaches to decarbonising heat and infrastructure.

Here in Scotland we see this heat being lost every day in the shape of the uninsulated communal drainpipes on the backs of traditional tenement flats, and yet vast swathes of tenements remain untreated because installing external cladding that could retain more of this lost heat in the building fabric is classed as changing the character of the building, and therefore requires planning permission (Changeworks, 2015). This, of course, makes no sense when you consider that the backs of traditional tenements were commonly more poorly constructed and decorated precisely because they wouldn't be seen from the street, and that the planners of yesteryear saw the societal need to permit the installation of external pipework to allow toilets to be installed in tenement flats.

This adherence to the past ignores the fact that traditional tenements were a marvel of the architectural expertise of their time, with architects experimenting with the design of windows, decorative features, and gardens, and incorporating shops into ground floors (Vanilla Square, 2016). If those same architects were designing tenements today they'd no doubt be experimenting with how modern technologies can be used in sympathy with the energy efficiency benefits of the high thermal mass in their original designs; and cladding pipework and fitting communal drains with heat exchangers would surely feature in their results.

For this, they might well look outwards to Hammarby Sjöstad, but like their ancestors they would also look inwards to the needs of those who would inhabit their creations, and that basic human desire for warm, comfortable homes. Between that ancient need for heat and the modern need to generate it with minimal greenhouse gas emissions, they would find it hard not to conclude that building-mounted solar thermal and the mixed solar thermal/heat storage/biomass DHS solutions being pioneered in Denmark present the most promising options for decarbonising heat, particularly in multiple occupancy buildings. But again, those solutions would be shaped by their own, Scottish, architectural culture and traditions, and consider the adage that '*if it ain't broke, don't fix it*'. So, on the outside those creations might look very similar to the tenements of yesterday, only without the exposed pipework, but on the inside, we would see the technologies of today. On the roofs we would see solar thermal and photovoltaic arrays, and down the road we would see larger arrays and community-scale wind and GSHP systems.

Looking further away, we'd see new woodlands appearing across the country, as native species are planted, managed, harvested and used in ways that evoke the past but meet the needs of today, and not just for biomass. This would bring those architects full circle as those woodlands would also provide new supplies of sustainable building materials from which they would construct and furnish their designs in ways that would serve to reconnect their occupants with their natural heritage, and this reconnection with nature may in turn help those occupants appreciate the need to defend it from the impacts of climate change.

Finally, they'd also see that climate change will place a new energy demand on their creations—the need to provide cooling. The Scottish Government does not yet view cooling as a policy priority (Beckmann, 2016) and until recently anyone trying to tell a Scottish policymaker that buildings in Scotland are already overheating would be met with something close to derision (been there, done that). However, there is now a growing body of substantive evidence that includes actual measurements from buildings (rather than modelled data) that is very difficult to refute. This shows not only that buildings in Scotland will begin to overheat sooner than previously predicted, but that there are already 'energy efficient' homes that are overheating outside of the summer season. Some of this is down to occupant behaviour, which itself will need to be tackled to support householders to adopt more energy efficient cooling behaviours, but this is only one factor. The bottom line here is that demand for cooling is going to increase sooner and faster than is currently being assumed (Drax, 2019; Morgan, 2018).

With a bit of forward thinking some of the energy that will be needed to meet this demand could be offset by simple passive solutions, for example the return of internal window shutters would be perfectly in keeping with Scottish architectural history, but the need to support householders to install such measures remains absent from the thinking behind SEEP and LHEES. In addition, and although perhaps less problematic than previous revisions, the Scottish Building Standards still serve to incentivise modern PassivHaus™-type designs over traditional passive designs incorporating high thermal mass (Scottish Government, 2017e). It may be arguable that future revisions of the Standards will deal with cooling by driving newer technologies but given the evidence that the performance of these is proving less impressive than previously predicted (Saffari et al., 2017), this would be yet another example of assuming there is a technological silver bullet on the way.

Yet the solutions for cooling have been with us for as long as humans have desired warmth—the sun, water, earth, and the ways we design our buildings. Traditionally Scottish buildings have been constructed of thick, solid stone walls, an ideal solution for regulating internal temperatures in a rapidly changing and generally hostile environment, and locally-sourced stone also happens to be a low carbon solution (Crishna et al., 2010), whilst another option is simply to use water for heat storage and thermal regulation (Gutai, 2015). Technologies such as district cooling and individual combined solar heating and cooling systems show good potential but will again need support to gain traction amongst developers and demand from householders (Mateus and Oliveira, 2009). However, if we really want to learn from others and from history we should turn to ancient Mesopotamia and modern Iran and redesign our buildings to provide natural and truly passive ventilation and air-conditioning (Roaf, 2005). Sound far-fetched? Well they've already been built in the UK, and two of the best examples—Coventry University's library and Queens Building at De Montfort University, Leicester—are already well over a decade old (Coventry University, 2018; De Montfort University, 2017).

6 Managing History

Those architects of yesteryear left a legacy to Scotland's cultural identity, but we have not managed it well. For all that has been done to tackle heating demand in new buildings and improve energy efficiency across the whole building stock, retrofitting low and zero carbon heating systems remains the elephant in the living room. Building-mounted solar thermal and individual GSHPs are perfectly viable options, but even in an ideal political environment the former competes with solar PVs for roof space on multiple occupancy buildings in urban areas, and the latter is a significant intervention requiring a sizable up-front investment.

ASHPs don't suffer this limitation but aside from how they actually perform in Scotland, they're not the most aesthetically pleasing additions to make to traditional buildings. Their impact might be mitigated by mediocrity when bolted onto a sterile office block or some of the mass-produced housing of the 1960s, but if bolted onto a majestic tenement they stick out like sore thumbs—it's not hard to imagine how local planners would react to a mass retrofit of ASHPs unless something could be done to mask their visual impact. Conventional electric cooling from simple fans to domestic refrigerant coolers may be part of the solution, and are likely to be a large part of it if householders adapt to overheating using the easiest means currently available to them, but remember that problem with future electricity demand?

So, here again, renewably fuelled DHS, inter-seasonal thermal storage, and heat recovery all come into play, along with community-scale GSHPs and (where feasible) water-source cooling. This is all possible, but it won't be easy. It means drilling holes in walls and roads to install new infrastructure, which means convincing the public that the benefits this disruption will being to their lives—reaching all the way into their homes—will be worth the inconvenience, and what many will see as government intrusion into their lives. It also means identifying and prioritising investment in those retrofit projects that will deliver the greatest efficiencies and reductions of waste heat by co-locating supply (including fuel supplies) with demand. It means engaging properly with local authorities, communities, professional associations, and academia before issuing consultations on proposals that are so half-baked they are almost laughable. It means accepting that Scotland cannot become Denmark tomorrow, and it won't ever become it without a national strategy that includes a Heat Planning Law. And, of course, to do all that means abandoning that mantra of not picking winners.

7 Conclusion—Managing the Decline?

When Geoff and I set out on this journey my original intention was to present a more positive vision of how Scotland could draw on its culture and history to shape its approach to decarbonising its heat supplies than in our previous book (Wood and Baker, 2017). That intention is reflected in the section on learning from the past, which was originally going to be the opening section. However, the more time I spent chasing figures and policy documents, sometimes to little avail, the more I was led back to questioning the reality of the risk of the perfect storm I forecast in our previous book.

I deliberately went looking for positive examples that could, at least in theory, be replicated in Scotland, and indeed I found them in the places the Scottish Government has been looking. But there remains an ocean between what the Scottish Government is observing and what it is learning from those observations. As I have argued, its current strategies are strewn with problems related to that lack of understanding, not least of the political and social histories that underpin the successes it is seeking to replicate, and its continued adherence to an irrational mantra. I have left it to other contributors to comment on how the decline of the fossil fuel industry as a whole can be managed, but even allowing for some miraculous expansion of heat recovery capacity and investment in passive solutions, energy for heating and cooling will still have to come from somewhere. The development of renewable and low carbon heat supplies will need to contribute to managing that decline by providing alternative ways of meeting demand for one of our most basic needs, as well as contributing to other environmental, social and economic goals. Naturally, that increase in capacity needs to be managed to meet or exceed the rate of the managed decline of the fossil fuel industry and, as other authors have noted, that decline needs to be fast.

Technologically, the biggest threat, and one I now realise I should have considered more in the previous book, looks set to come from the predicted rapid expansion of electric vehicles and the hydrogen economy competing for renewable electricity. These are risks that could be averted fairly easily and, considered in isolation, would not be enough to predict that perfect storm. However, the biggest problem is that the solutions that will need to be employed to mitigate them will need to be deployed strategically, and the infrastructure needed to enable them to supply cheap, low and zero carbon heat, needs to be put in place now. In their current forms, and particularly with regard to equitably delivering those solutions to fuel poor and otherwise vulnerable householders, SEEP, LHEES, and the proposals for the new publicly owned energy company fall far short of meeting those needs.

It is time for a radical re-think. The more I have been questioning the risk of that perfect storm in the 2020s, the more concerned I have become that the time left to avert it is rapidly running out. I hope I'm wrong.

References

Aberdeen City Council. 2017. *District Heating*. Aberdeen: Aberdeen City Council.

Andreadis, G., Roaf, S. and Mallick, T. 2013. Tackling Fuel Poverty with Building-Integrated Solar Technologies: The Case of the City of Dundee in Scotland. *Energy and Buildings* 59(April): 310–320.

Arteconia, A., Hewittb, N.J. and Polonarac, F. 2013. Domestic Demand-Side Management (DSM): Role of Heat Pumps and Thermal Energy Storage (TES) Systems. *Applied Thermal Engineering* 51(1–2): 155–165.

Atterson, B., Restrick, S., Baker, K.J., Mould, R., Stewart, F. and Melone, H. 2018. *Down to the Wire: Research into Support and Advice Services for Households in Scotland Reliant on Electric Heating*. Report for the Consumer Futures Unit, Citizens Advice Scotland.

Baker, K.J. 2017. Renewable Heat: The Perfect Storm? In: Wood, G. and Baker, K.J. (Eds.) *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Palgrave Macmillan.

Baker, K.J., Emmanuel, R. and Phillipson, M. 2012. *Support for RPP2—Housing Futures*. Report for ClimateXChange Scotland.

Baker, K.J., Mould, R. and Restrick, S. 2016. *Proiseact Spéird—The Spéird Project: Understanding Influences on Fuel Poverty in Rural and Island Scotland*. Final Report for the Eaga Charitable Trust.

Baker, K.J., Mould, R. and Restrick, S. 2018. *Rethink Fuel Poverty as a Complex Problem*. Nature Energy, July 2, 2018.

Baker, K.J., Morgan, G., Mould, R. and Wright, I. 2019. *Achieving Our Ambitions: The Role of Scotland's Publicly Owned Energy Company and the Case for a Scottish Energy Development Agency*. A Common Weal Policy Paper.

Beckmann, K. 2016. *Energy Demand for Heating*. ClimateXChange Scotland Publication.

CarbonPlan. 2018. *Calside Renfrewshire: ECO Biomass Heat Network*. London: CarbonPlan Ltd.

Changeworks. 2015. *Insulating Your Tenement*. Edinburgh: Changeworks.

Church, E., Hytiris, N., Emmanuel, R. and Aaen, B. 2013. *The Glasgow Energy from Mine-Workings Project: Developing Confidence in an Unconventional Energy Source*. Glasgow Caledonian University, Scottish Power, and the British Geological Survey.

City of Edinburgh Council. 2015. *Edinburgh's Sustainable Energy Action Plan 2015–2020*. City of Edinburgh Council, UK.

Clarke, J.A., Johnstone, C.M., Kelly, N.J., Strachan, P.A. and Tuohy, P. 2008. *The Role of Built Environment Energy Efficiency in a Sustainable UK Energy Economy*. *Energy Policy* 36(12): 4605–4609.

Coventry University. 2018. Lanchester Library Building, Coventry University, UK.

Crishna, N., Goodsir, S., Banfill, P. and Baker, K.J. 2010. *Embodied Carbon in Natural Building Stone in Scotland*. Historic Scotland Publication.

DBEIS. 2017. *Energy and Climate Change Public Attitude Tracker: Wave 21*. London: Department for Business, Energy and Industrial Strategy.

DBEIS. 2018. *Heat Network Investment Project: Case Study Brochure*. London: Department for Business, Energy and Industrial Strategy.

De Montfort University. 2017. *New Practice Case Study 102: The Queens Building, De Montfort University—Feedback for Designers and Clients*. Leicester: Institute of Energy and Sustainable Development, De Montfort University.

DECC. 2013. *Summary Evidence on District Heating Networks in the UK*. London: Department for Energy and Climate Change.

Drax. 2019. *How the Heatwave Affects Electricity Demand*. Report by Imperial Consultants, London, UK.

Druckman, A. 2013. *Taking a Whole Systems Approach: Accounting for Scope 3 Emissions and Avoiding Unintended Consequences*. The Initiative for Carbon Accounting (ICARB), 5th International Conference on Carbon Accounting, Edinburgh, 13 March 2013.

Ecotricity. 2018. *Electric Car Charging Stations*. Ecotricity Publication.

Emmanuel, R. and Baker, K.J. 2012. *Carbon Management in the Built Environment*. London and New York: Routledge.

Envac. 2017. *Hammarby Sjöstad—A Beacon of Sustainable Urban Development*. Envac Publication.

EST. 2017. *Renewable Heat in Scotland, 2016*. Report by the Energy Saving Trust for the Scottish Government.

Euroheat & Power. 2016. *Glasgow Commonwealth Games' Athletes Village*. Brussels, Belgium: Euroheat & Power.

Euroheat & Power. 2017a. *Country Profiles: District Energy in Germany*. Brussels, Belgium: Euroheat & Power.

Euroheat & Power. 2017b. *Country Profiles: District Energy in Norway*. Brussels, Belgium: Euroheat & Power.

EVAS. 2018. *Rapid Chargers in Scotland*. Electric Vehicle Association Scotland.

Forestry Commission. 2017. *First Release: Woodland Area, Planting & Publicly Funded Restocking: 2017 Edition*. Forestry Research, Edinburgh, UK.

French Government. 2018. *Energy Transition*. French Government Publication.

Gaffney, A., Huang, V., Maravilla, K. and Soubotin, N. 2017. *Hammarby Sjolstadt, Stockholm, Sweden: A Case Study*. CP 249 Urban Design in Planning 2007.

Greening, B. and Azapagic, A. 2014. Domestic Solar Thermal Water Heating: A Sustainable Option for the UK? *Renewable Energy* 63: 23–36.

GSTE. 2014a. *Denmark: 23 MWth Cover 55 % of Heat Demand of 1,500 Households*. Global Solar Thermal Energy Council, United Nations Environment Programme, Milan, Italy.

GSTE. 2014b. *Sweden's Solar Heat Market on Hold*. Global Solar Thermal Energy Council, United Nations Environment Programme, Milan, Italy.

GSTE. 2014c. *France, District Heating*. Global Solar Thermal Energy Council, United Nations Environment Programme, Milan, Italy.

Gutai, M. 2015. Liquid Engineering: Towards New Sustainable Model for Architecture and City. In: Zhao, P. (Ed.) *Planning for Sustainable Cities—Urban Challenges, Policy Responses and Research Agenda*. China: Center for Urban and Transport Planning, Peking University.

IET. 2012. *Solar Energy Awakening in Norway*. Institute for Energy Technology, Kjeller, Norway.

Mateus, T. and Oliveira, A.C. 2009. Energy and Economic Analysis of an Integrated Solar Absorption Cooling and Heating System in Different Building Types and Climates. *Applied Energy* 86(6): 949–957,

Mauthner, F., Weiss, W. and Spörk-Dür, M. 2014. *Solar Heat Worldwide-Markets and Contribution to the Energy Supply 2011*. Technical Report, AEE-Institute for Sustainable Technologies, Gleisdorf, Austria.

Morgan, S. 2018. No 'One Size Fits All' Solution to Decarbonise Heating and Cooling. *Euractiv*, March 28, 2018.

Morris, C. and Jungjohann, A. 2017. Energize the People to Effect Policy Change. *Nature* 551(7682): 138–140.

Mould, R. 2018. *An Investigation of the District Heating—Fuel Poverty Nexus*. PhD Thesis, School of Engineering and the Built Environment, Glasgow Caledonian University.

Mould, R. and Baker, K.J. 2017. Uncovering Hidden Geographies and Socio-Economic Influences on Fuel Poverty Using Household Fuel Spend Data: A Meso-Scale Study in Scotland. *Indoor and Built Environment 20*(7): 1–23.

Mould, R., Baker, K.J. and Emmanuel, R. 2014. Behind the Definition of Fuel Poverty: Understanding Differences Between the Fuel Spend of Rural and Urban Homes. *Queens Political Review* II(2): 7–24.

NNFCC. 2017. *Biogas Map*. NNFCC and the UK Department for Environment, Food, and Rural Affairs (Defra), UK.

Ofgem. 2015. *Insights Paper on Households with Electric and Other Non-gas Heating*. Office of Gas and Electricity Markets, UK.

PlanEnergi & Niras. 2015. *Dronninglund Solar Thermal Plant*. Technical Report, Dronninglund District Heating.

Pridmore, A., Smith, A., Baker, K.J., Ahlgen, C. and Williamson, T. 2017. *Evidence Review of the Potential Wider Impacts of Climate Change Mitigation Options: Built Environment Sector*. Report for the Scottish Government.

REA. 2016. *Energy Storage in the UK: An Overview*. Renewable Energy Association, UK.

Roaf, S. 2005. *Air-Conditioning Avoidance: Lessons from the Windcatchers of Iran*. Proceedings of the International Conference "Passive and Low Energy Cooling for the Built Environment", May 2005, Santorini, Greece, pp. 1053–1057.

Saffari, M., de Gracia, A., Ushak, S. and Cabeza, L.F. 2017. Passive Cooling of Buildings with Phase Change Materials Using Whole-Building Energy Simulation Tools: A Review. *Renewable and Sustainable Energy Reviews* 80: 1239–1255.

Scottish Government. 2009. *Climate Change (Scotland) Act 2009*. Scottish Government Publication.

Scottish Government. 2011. *2020 Routemap for Renewable Energy in Scotland*. Scottish Government Publication.

Scottish Government. 2013a. *Study into the Potential for Deep Geothermal Energy in Scotland: Volume 1*. Scottish Government Publication.

Scottish Government. 2013b. *Low Carbon Scotland: Meeting our Emissions Reduction Targets 2013–2027: The Second Report on Proposals and Policies (RPP2)*. Scottish Government Publication.

Scottish Government. 2016a. *Action on Fuel Poverty*. Scottish Government Publication.

Scottish Government. 2016b. *Update on Renewable Heat Target and Action—2016*. Scottish Government Publication.

Scottish Government. 2017a. *Scottish Energy Strategy: The Future of Energy in Scotland*. Scottish Government Publication.

Scottish Government. 2017b. *Scotland's Energy Efficiency Programme: Second Consultation on Local Heat & Energy Efficiency Strategies, and Regulation of District and Communal Heating*. Scottish Government Publication.

Scottish Government. 2017c. *Consultation on Heat & Energy Efficiency Strategies, and Regulation of District Heating*. Scottish Government Publication.

Scottish Government. 2017d. *Energy Statistics for Scotland*. Scottish Government Publication.

Scottish Government. 2017e. *Building Standards Technical Handbook 2017: Domestic*. Scottish Government Publication.

Scottish Government. 2018. *Publicly Owned Energy Company*. Scottish Government Publication.

SEPA. 2010. *Biomass and Air Quality Guidance for Scottish Local Authorities*. Scottish Environmental Protection Agency, Glasgow, Scotland.

SEPA. 2018. *Energy from Waste Sites*. Scottish Environmental Protection Agency, Glasgow, Scotland.

SIE. 2012. *Energy Consumption in Households in 2009*. Statistical Information and Elaborations, Department of Energy, Warsaw, Poland.

Siemens. 2011. *Energy from Waste—Shetland Case Study*. Siemens Industry Automation and Drive Technologies.

SNH. 2017. *Woodland Expansion Across Scotland*. Scottish Natural Heritage, Inverness.

Stadler, C. 2014. *Large Scale Solar Thermal Power Plants for District heating*. ARCON Solar, November 2014.

Upham, P. and Shackley, S. 2007. Local Public Opinion of a Proposed 21.5 MW(e) Biomass Gasifier in Devon: Questionnaire Survey Results. *Biomass and Bioenergy* 31(6): 433–441.

Vanilla Square. 2016. *A History of Glasgow's Tenements*. Vanilla Square, Glasgow, UK.

Wood, G. and Baker, K.J. (Eds.). 2017. *A Critical Review of Scottish Renewable and Low Carbon Energy Policy*. Palgrave Macmillan.

Part IV

Epilogue

23

Managing the Decline of Fossil Fuels: A Long Goodbye?

Geoffrey Wood

The contributions to this book highlight a number of challenges and frustrations, opportunities and surprises facing attempts to manage the decline of fossil fuels, representing a complex interplay of factors, both optimistic and pessimistic and often a mixture of both, as the world grapples with the shift towards a low carbon energy future. Prior to looking at these factors, it is pertinent to point out that the aim of this book is not to provide all the answers. Indeed, given the complexity of the task, it is likely that there are no simple answers or one-size-fits-all solutions (as the chapters in this book show). Rather, in addition to providing critical up-to-date rich context and analysis of approaches to managing the decline of fossil fuels, it seeks to facilitate thinking about how to do so from a range of perspectives, methodologies and jurisdictions and highlight trends and issues that we need to be aware of in managing the decline.

Challenges and *frustrations* because the world is still addicted to and heavily dependent on fossil fuels for the power, heating/cooling and transport sectors (Chaps. 1, 4, 5, 6, 7, 8, 9, 11, 14 and 20); because some nations are still intent on maximising the extraction and consumption of every last drop of hydrocarbons from their jurisdictions (Chaps. 7, 8, 14 and 15), although arguably not all countries have the luxury of established and stable low carbon energy legal and governance frameworks and access to technology, expertise, labour and finance that the developed world has (Chaps. 12 and 18); because lessons

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still need to be learned in how to approach the energy transition and reduce reliance on fossil fuels (Chaps. 6, 14, 16, 18, 20 and 22); because there is still a need for a radical rethink (Chaps. 6, 18, 19, 20 and 22); because not all low carbon replacement options for fossil fuels are as benign or risk free as they are typically portrayed (Chaps. 2, 3 and 17); because new technologies are driving the use of fossil fuels (Chaps. 2, 7 and 14); because debate is not always moving forward in step with evidence to support the energy transition (Chaps. 6, 12 and 20); because the prospects for decarbonising the heat sector remain fragile as lessons are still not being learned (Chap. 22); because of existing, long-term interdependencies between government and the fossil fuel sector which lead to questioning the capacity and role of government in managing the decline of fossil fuels given that they are often a part of the sector (Chaps. 6 and 20); because non-governmental actors and incumbents continue to play a role in aggravating attempts to reduce fossil fuel use and resultant GHG emissions (Chaps. 8 and 12); because the danger of high-carbon lock-in remains (Chaps. 1, 6, 8 and 13); because not all alternatives to fossil fuels are intended to completely replace them but rather to compliment them (Chaps. 2 and 17); because energy regulatory and market design reform still lags behind what is required to transition from a conventional high carbon system to a renewable low carbon system, despite acknowledgment of what the barriers are and how to overcome them (Chaps. 4, 16 and 22), although there is indeed progress as the case studies in this book show; because there is still a gap between the desired low carbon future and present realities (Chaps. 5, 6, 8, 9, 11, 12 and 14); because the debate still remains largely polarised (Chaps. 2, 8 and 18); and because the transition from a complex socio-technical system such as the fossil fuel regime is likely to be a complex and drawn out affair as past experience has shown (Chaps. 13 and 18).

Opportunities and *surprises* because many nations, both developed and undeveloped, are making concerted effort to drive renewable and low carbon energy deployment and reduce fossil fuel use in the face of fundamental difficulties in doing so for a variety of reasons (Chaps. 2, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 21 and 22); because reducing fossil fuel production occurs at times outwith climate policy strategy, although it is no less the effective (Chap. 15); because the inherent injustices in fossil fuels should mean that energy transition is inevitable (Chaps. 18, 19 and 20); because technology options to abate climate-damaging carbon emissions have the potential to play an interim role in abating emissions from the combustion of fossil fuels (Chaps. 2 and 7); because some nations and sub-national authorities are making a stand by opting for the first time to not extract fossil fuels in their jurisdictions (Chap. 15);

because at least some elements of approaches to managing the decline of fossil fuels are occurring quite radically (Chaps. 9 and 17); because energy justice principles are now starting to be applied to the fossil fuel industry to provide more appropriate criteria to guide the development of energy resources management in light of the adverse effects of climate change (Chaps. 18, 19 and 20); because there is ample evidence of innovation in terms of policy, approaches and decision making (Chap. 16); because the de facto dominance of economics and economic elites in approaches to a low carbon transition is being increasingly questioned through the lens of just transitions (Chaps. 18 and 20); and because energy storage is coming of age, with huge potential to play a wide role in supporting the transition from fossil fuels (Chap. 21).

In addition to looking at how to manage the decline of fossil fuels and the current state of play in doing so, one of the key themes of this book, as stated at the beginning, is to ask if we can expect the necessary decline to be a 'long goodbye' or not? Recognising that it is impossible, at least at this stage, to provide a definitive date (beyond the IPCC warnings), it is worth attempting to synthesise the findings of the chapters. What then can be determined from the above?

That energy systems are in the middle of significant overhaul is obvious. For many countries, however, at long last the energy sector is on the verge of significant reform. Yes, for the time being fossil fuels remain dominant. Yes, the vested interests of some governments, incumbents and actors constrain the energy transition with a Janus-like approach to promoting low carbon and renewable alternatives with one face, whilst pushing high carbon technologies and fuels with the other. Overall, then, there is a sense that we are collectively sitting on the edge of a meaningful energy transition. Fossil fuel industries remain entangled and embedded with political, economic and development agendas in many parts of the world, as emphasised by the rise of unconventional hydrocarbons and oil sands. There is also concern over who is 'steering the ship' and what the ultimate goal of energy transition is, and these are more political and economic issues rather than scientific. Invoking the ancient Roman god Janus might be a particularly apt way to envisage energy system transition as it currently stands: usually depicted as having two faces, looking to the past and to the future, this book contends that the energy sector is in such a state of flux between the old (conventional, centralised, high carbon) and the new (alternative, decentralised, low carbon), but clearly no new state has yet been achieved. And, despite progress to date, the 'tipping point' between the two states is yet to be reached. Whilst elsewhere it has been argued that the other critical tipping point, for developing renewable energy, has been reached,[1] the findings of this book suggest that no such threshold has been met for fossil fuels. And here in lies a paradox of transition: growth in renewables and low carbon energy sources and no concomitant decline in fossil fuels. Simply put, there needs to be a decoupling of fossil fuels and renewable/low carbon energy; the latter cannot just simply pick up the slack of increasing demand or serve difficult to reach places. Unaddressed and unresolved, all this will do is serve to bloat the energy system with the same problems for issues such as climate change and energy security. At the same time, three further points require consideration. Not all countries or regions will be able to reduce fossil fuel use and achieve a low carbon energy transition at the same rate. In short, decarbonisation will be at least a two-speed process (although this should not be abused for simply economic gain). There is also the perverse effect of managing the decline. Any timescale to curtail their use could lead to a glut in fossil fuel use as nervous countries rush to market before the opportunity disappears. New technologies are also unlocking previously unexploited fossil fuel reserves, heralding what might be called a new 'hello' to carbon intensive sources. This indicates that we might be looking at a long goodbye to fossil fuels.

But Janus, the two-faced god, is also known as the god of transitions who presided over the beginning and end of conflict. What this book hopefully shows, then, is that there are green shoots interlacing and overlapping throughout the energy systems of many nations across the globe. These are not just cracks in the fossil-fuel system; they are signs of system change and transition. Despite the challenges and frustrations highlighted above, positive steps have already and continue to be taken and with apparent confidence: formerly niche technologies such as renewable and low carbon energy alternatives are an increasingly viable alternative to fossil fuels; and some countries have, for the first time in the fossil fuel age, the conviction to say no to new or existing fossil fuels. It would have been unthinkable to imagine a state deciding not to extract and use hydrocarbon reserves even a few decades ago.[2] In short, traditional approaches are being queried and found lacking and alternative approaches are becoming mainstream and normalised. This book shows that it is possible to manage the decline of fossil fuels. The chapters show this for a diverse range of countries and scenarios. Further, it aims to provide the

[1] See Wood (2017) for a discussion on whether renewable energy sources have reached a tipping point not just in terms of capacity installed and generational output, but also in terms of economic viability and mainstream acceptance.

[2] Countries like Denmark that were early pioneers in renewable programs typically did so because they had limited or no fossil fuel reserves and were heavily dependent on such imports. Further, such change was often provoked by external shocks, including the oil crises of the 1970s.

confidence to visualise a future where we have risen to the demands of climate change and achieved the ultimate goal of not just reducing fossil fuels but a zero carbon future that works for all. So the question remains, is there sufficient time left to do so within the urgent timeframe that we as a species have set ourselves?

Reference

Wood, G. 2017. Has Renewable Energy Reached the 'Tipping Point'? *Sputnik News*, January 12, 2017. https://sputniknews.com/radio_level_talk/201701121049520046-renewable-energy-tipping-point/

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Our Time Is Up

Keith Baker and Geoffrey Wood

Our time is up.

As the editors of the *Handbook of Managing Fossil Fuels and Energy Transitions*, we would be gravely amiss if we did not make this clear so let us repeat it again: *our time is up*. Since we began writing this book in 2017, we have seen the United Nations announce that we have just 12 years left to prevent a climate catastrophe, we have seen school children take to the streets to demand action on climate change, and we have seen governments declare climate emergencies. These are unprecedented acts but they will come to little or nothing if we fail to turn those words into actions, and much of the responsibility for that has to fall on policy makers, the energy industry, and all the many stakeholders who will need to be engaged and involved in delivering the transition to a fully decarbonised society. We should be in no doubt that achieving this transition ultimately means completely eliminating three major industries—coal, oil and gas—whose global gross domestic product easily runs into tens of trillions of dollars. And because *our time is up*, this must be

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achieved in a time-frame that correlates precisely with the warnings from the United Nations and others.

This means that those industries, and the governments who permit them to operate, must limit the extraction of fossil fuels to, at most, two thirds of oil, half of gas, and under twenty percent of coal from currently available resources. This means enabling the millions of people employed by those industries to transfer their knowledge and skills to developing and deploying non-fossil fuel technologies, creating millions more new jobs in renewable and low carbon energy industries, and training the workers we will need to fill them.

Beyond the energy sector, this means building the supply chains we need to supply non-fossil fuels, which means policies to decarbonise the energy sector need to be enabled and supported by policies covering buildings, planning, transport, agriculture, forestry, land use (and land ownership), and every other aspect of our environment, economy and society, and at every level of them. This means every one of us will be affected by this transition, from the wealthy who will need to reduce their energy use, to the poorest who will need to be enabled to use energy if the transition is to be an equitable one: we need to recognise the hundreds of millions of people still without access to energy and those nations currently lacking the capacity to join the energy transition. And achieving that latter goal means ensuring the best possible evidence is brought to bear to ensure the choices we make as part of delivering the transition do not result in unintended consequences that serve to exacerbate inequality and inequity, be that between individuals, communities, or countries.

We should also be in no doubt that we have left it until the last minute to make this transition. It is now 172 years since Congressman George Perkins Marsh told the Agricultural Society of Rutland County (Vermont, USA) that "*But though man cannot at his pleasure command the rain and the sunshine, the wind and frost and snow, yet it is certain that climate itself has in many instances been gradually changed and ameliorated or deteriorated by human action*". It is now 81 years since the British engineer Guy Callendar found that global temperatures had risen over the previous century and linked that change to increases in the emissions of carbon dioxide from the combustion of fossil fuels. It is now 62 years since oceanographer Roger Revelle and chemist Hans Suess found that seawater will not absorb all the additional carbon dioxide entering the atmosphere, as many had previously assumed. It is 31 years since the establishment of the Intergovernmental Panel on Climate Change, 29 years since its First Assessment Report, and 27 years since the signing of the United Nations Framework Convention on Climate Change at the Rio Earth Summit. We cannot claim not to have known and not to have been able to do something about it, and yet we now have just 12 years left to prevent a climate catastrophe.

We could have started saying goodbye to fossil fuels way back when people first started finding evidence that consuming them could be harmful to our planet, and we could have applied the same principles and technologies to generating energy from alternative sources. But, like the tobacco industry, the fossil fuel industry has used its power and influence to thrive long beyond the time where it should have declined and ceased to exist. So, in a very real sense we have had the option of saying a long goodbye to fossil fuels for many years and been aware of the risks for longer still. This long goodbye must now be managed into a final farewell in little over a decade, but with a safety net for all those it will carry with it.

It would be an understatement to say that we live in troubling times: climate change is such an overwhelming issue and managing the decline of fossil fuels and transitioning to a low carbon energy system is challenging in the least. We might wish that we did not have to deal with it, a sentiment echoed by Frodo Baggins in The Lord of the Rings: "*'I wish it need not have happened in my time', said Frodo. 'So do I', said Gandalf, 'and so do all who live to see such times. But that is not for them to decide. All we have to decide is what to do with the time that is given to us'*" (Tolkien, 2009). However, if you are reading this the chances are you will have some role, however small or distant, in managing that decline, and we hope that the range of evidence and perspectives collected in this book will be of some value in whatever roles you will play. We also hope that the arguments made by our contributors serve to demonstrate the scale and urgency of the actions we need to be taking, and why we cannot afford to waste any more time. Many of you will live to see how successful we as a species will be in achieving the changes we must make to avert a climate catastrophe, and we owe it to the generations to come and the memories of those who have come before us to ensure that we do so.

And so, we end on a quote from the next generation. Just before we went to press Greta Thunberg told the World Economic Forum, "*I am here to say, our house is on fire… I want you to act as you would in a crisis. I want you to act as if our house is on fire. Because it is.*" So, we urge all of you, using whatever knowledge, skills and influence you can bring to bear, to act like your houses are on fire, because *our time is up*.

Dr. Geoffrey Wood & Dr. Keith Baker
June 2019

Reference

Tolkien, J.R.R. 2009. *The Fellowship of the Ring*. HarperCollins.

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G. Wood, K. Baker (eds.), *The Palgrave Handbook of Managing Fossil Fuels and Energy Transitions*, https://doi.org/10.1007/978-3-030-28076-5

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