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Daniel Scholten *Editor*

The Geopolitics of Renewables

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The Geopolitics of Renewables

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Acknowledgements

The Geopolitics of Renewables is the first volume to specifically explore the implications for interstate energy relations of a transition towards renewable energy; a novel topic that will undoubtedly garner more attention in the coming decades. It represents the culmination of the collaboration among a growing community of researchers drawn to this surprising gap in the literature. It is safe to say that without their enthusiasm and support, it would have proved too daunting to make this new phenomenon accessible and understandable to readers. I would therefore like to take this opportunity to thank all those that contributed to its realization.

The origins of the volume can be traced back as far as Spring 2011 when I was thinking about life after my dissertation and decided to merge my interests in renewable energy and international relations. While scribbling down some first ideas, googling the topic highlighted its true novelty: only the conference paper by David Criekemans explicitly addressed it. After meeting him in the beautiful city of Antwerp enthusiasm struck me. This was later reinforced at the first workshop on the geopolitics of renewables in Delmenhorst, Germany, in December 2011, organized by Karen Smith Stegen. While I was horribly unprepared, not having a paper to back me up, it introduced me to Rick Bosman, got me thinking on how to tackle the conceptual and practical void of this new topic, and led to the organization of a workshop together with David Criekemans at the political science day in 2012. While ideas were piling up, not much was put on paper due to the birth of my son and other priorities at Delft. Getting impatient and frustrated, I called Rick Bosman at the end of 2012, leading to a first conference paper in May 2013, and some short popular pieces by the end of Summer that year. These would lay the groundwork for the publication of "the geopolitics of renewables" in Technological Forecasting and Social Change in 2016.

The last few years, bits and pieces of renewables' geopolitical impact have gotten more academic attention and there is a noticeable increase in interest by policy makers in the energy security implications of renewable energy technologies. Still, publications on the topic have remained scarce. It became time for someone to take this challenge on. After inviting David, Karen, Thijs, Varun, Sagatom, Thomas, Duncan, Kanika, Rick, Marloes, and Susann, the team to write a volume was largely assembled by the end of September 2016 and the general contours of the volume had taken shape. A hick-up in the process was Rick's leave of absence due to personal circumstances, which led to the inclusion of Fritz, Nadejda, and Antonella's chapter, the latter of which I met at the workshop on the geopolitics of renewables in March 2017 in Berlin. Fortunately, Rick was back in time to help out with the conclusion. Now, with the publication of the book, I can only express my utmost gratitude to all contributors for realizing this volume. Their willingness to incorporate my remarks, their occasional stubbornness in this regard, and their ability to deliver past deadlines prove that I had the privilege to work with true academics. In all, I very much look forward to continue working with them on this thrilling topic.

Finally, I wish to acknowledge Springer for their interest and proactive approach in contacting me. It gave me the push I needed to take this challenge on. I also thank my colleagues at the Faculty of Technology, Policy and Management for giving me the opportunity to pursue a topic that is not exactly the core business of a technical university. Lastly, thanks go to the EUCERS staff at King's College for allowing me to finish this volume during my time in London.

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About the Editor

Daniel Scholten is Assistant Professor at the faculty of Technology, Policy and Management of Delft University of Technology. He specializes in the geopolitics of renewables and the governance of renewable energy systems. His research and teaching combines engineering insights on renewable energy systems with institutional economics, political science, and international relations to identify, interpret, and address the societal implications of a transition to renewable energy. He has published in such journals as Technical Forecasting and Social Change, Energy, Energies, Energy Research and Social Science, Journal of Common Market Studies, Sustainability, and European Review. In the past, Dr. Scholten has been an affiliated research fellow at the Energy Programme Asia of the International Institute for Asian Studies in Leiden and a lecturer of International Political Economy at Webster University Leiden. In addition, he was the managing editor of the international journal Competition and Regulation in Network Industries between 2011 and 2016. He defended his dissertation on the organizational requirements of future energy systems at the TU Delft in 2012 and holds degrees in Political Science (Radboud University, 2003) and International and European Relations (University of Amsterdam, 2006, with distinction).

Contributors

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Antonella is currently a member of the European Commission's expert group on electricity interconnection targets and has previously been an expert member of the World Economic Forum (WEF)'s 2014–2016 Global Agenda Council on the Future of Electricity. In 2015, she was named one of Tällberg's 2015 five Global Leaders for her commitment to a sustainable energy future and combating climate change. She is also a senior scientist at the Potsdam Institute for Climate Impact Research

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Rick Bosman is Ph.D. researcher and advisor at the Dutch Research Institute for Transitions, Erasmus University Rotterdam. Rick's work focusses on the energy transition, both in the Netherlands and abroad. Particularly, he is interested in how (incumbent) actors deal with transformative change. His work is published in peer-reviewed academic journals, such as Technological Forecasting and Social Change, Sustainability and Environmental Innovation and Sustainability Transitions.

Next to his scientific work, Rick advises high-level decision makers, including the Finnish Ministries of Economic Affairs and Employment, Agriculture and Forestry, and the Environment on their joint Bioeconomy Strategy; The Dutch Ministry of Foreign Affairs on the Geopolitics of the Energy Transition; and Dutch parliament on the effects of Germany's Energiewende. Furthermore, Rick is initiator of the post-academic masterclass "Accelerating the Energy Transition" and he regularly takes part in public debate through writing for popular media such as the Financial Times and Energy Post and giving public lectures.

Rick holds a Bachelor degree in Environmental Sciences from Utrecht University (NL) and a Master degree in Renewable Energy Management from University of Freiburg (GER). Before starting his Ph.D., Rick gained work experience in the (renewable) energy sector at the Netherlands Embassies in Australia and Germany and with the Clingendael International Energy Programme in The Hague.

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Prior to her association with CEEW she has worked at the Renewable Energy Policy Network for the twenty-first Century (REN 21) Secretariat in Paris. Kanika specialized in international cooperation and sustainable energy policy and researched energy policy issues in developing countries around the world with a specific focus on renewable energy, energy efficiency and gender. She has also worked with GIZ on sustainability reporting.

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Marloes Dignum studied Innovation Sciences in Eindhoven university of technology and holds a Ph.D. from the same university. Her Ph.D. research centered on the shaping capabilities of large technological visions in societal and institutional change processes, focusing on hydrogen as a potential alternative to fossil fuel. She worked a postdoctoral researcher at Delft University of Technology in the fields of transition studies and responsible innovation. Her postdoctoral work focused on the energy domain and included analysis on the public acceptance of new energy technologies, institutional and procedural development of new energy systems, public values and participatory decision making, collaboration and scaling energy sustainability. Since March 2017, she works as a researcher on urban innovation at The Netherlands Environmental Assessment Agency (PBL). In this position, her research focuses on urban innovation and experimentation in relation to transitions.

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Fritz Reusswig is a senior researcher at the Potsdam Institute for Climate Impact Research (PIK) and the deputy head of the department "Transdisciplinary Concepts and Methods". He is a sociologist and philosopher by training (Ph.D. at Goethe University of Frankfurt am Main, Habilitation Thesis at Potsdam University). He is working on climate change mitigation and adaptation strategies for cities, on the public discourse on climate change and nature protection, and on renewable energy conflicts. Fritz is teaching environmental sociology at the Humboldt University of Berlin.

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Thomas Sattich is affiliated with the University of Stavanger, Norway. His research focuses on the European politics of energy. Having been based in Brussels for 5 years, Dr. Sattich has first-hand experience with EU-level energy politics and the diverse set of EU energy policies. His main focus lies on energy infrastructure, particularly electricity grids, international flows of energy, and the integration of renewables. Analyzing, converting, and visualizing energy data are among his favorite activities. Beyond, Thomas Sattich is interested in the overlap between energy and industrial policy as well as the energy relations between European and non-European countries. In this context, the relationship between European and Chinese energy policy is one of the subjects Thomas Sattich is working on.

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Dr. Sivaram was previously senior advisor for energy and water policy to Los Angeles Mayor Antonio Villaraigosa, strategic advisor on energy policy to the office of New York Governor Andrew Cuomo, and a consultant at McKinsey & Company. *Forbes* named him one of its 30 under 30 in law and policy, and *Grist* named him one of its top 50 leaders in sustainability. He holds a Ph.D. in condensed matter physics from Oxford University, where he was a Rhodes Scholar.

Karen Smith Stegen is a professor of political science and the coordinator of the International Relations: Politics and History (IRPH) undergraduate program at Jacobs University, located in Bremen, Germany. In addition to her Ph.D. in political science (Northwestern University), she holds an International MBA (Moore School, University of South Carolina). Her interest in geopolitics and energy stems from her 6-year experience working for an international energy company. In 2011, Dr. Smith Stegen organized the first-ever workshop specifically examining the geopolitics of renewable energies, which drew attendees from around the world. Many of her publications focus on energy and international relations and appear in peer-reviewed journals such as Energy Policy, Energy, and the Journal of Transatlantic Studies. Dr. Smith Stegen is also a featured speaker at conferences and workshops.

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Abbreviations

AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
ADB	Asian Development Bank
AGE7	Advisory Group for Energy
AT&C	Aggregate Technical & Commercial
BNEF	Bloomberg New Energy Finance
BOO	Build, Own, and Operate scheme
BP	British Petroleum
BRI	Belt and Road Initiative
BYD	Build Your Dreams
CACR	Central Asia and Caspian Region
CAN	Climate Action Network
CAPEX	Capital Expenditures
CBDR	Common But Differentiated Responsibility
CCS	Carbon Capture and Storage (technology)
CDM	Clean Development Mechanism
CdTe-cells	Cadmium Telluride cells
CEM	Climate and Energy Model
CENTCOM	US Central Command
CERC	Clean Energy Research Center
CIEP	Clingendael International Energy Program
CIGS-cells	Copper Indium Gallium Selenide cells
CO_2	Carbon Dioxide
CSEM	Swiss Centre for Electronics and Microtechnology
CSP	Concentrated Solar Power
CTCN	UNFCCC's Climate Technology Centre and Network
DAD	Decide–Announce–Defend
DC	Direct Current
DERs	Distributed Energy Resources
DfiD	UK Department of International Development

DG-TREN	Directorate-General Transport and Energy
DII	Desertec Industrial Initiative
DISCOM	Distribution Company
DOE	Department of Energy
DSO	Distribution System Operator
EC	European Commission
EEG	Erneuerbare Energien Gesetz (Germany)
EIA	Energy Information Administration
ENTSO-E	European Network of Transmission System Operators for Electricity
EP	European Parliament
ERGEG	European Regulators' Group for Electricity and Gas
EU	European Union
EVs	Electric Vehicles
FDR	Franklin Delano Roosevelt
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIB	Green Investment Bank
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Development Fund)
GW(h)	Gigawatt (hours)
HEU	Highly Enriched Uranium
HVDC	High-Voltage Direct Current
IAEA	International Atomic Energy Agency
ICT	Information and Communication Technology
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IOC	International Oil Company
IoT	Internet-of-Things
IPE	International Political Economy
IPI	Iran–Pakistan–India
IPO	Initial Public Offering
IPR	Intellectual Property Rights
IR	International Relations
IRENA	International Renewable Energy Agency
IS	Islamic State
ISA	International Solar Alliance
KfW	German Government Development Bank
KM	Kilometer
KW(h)	Kilowatt (hours)
LNG	Liquefied Natural Gas
LWRs	Light Water Reactors
MENA	Middle East and North Africa

MI	Mission Innovation
MLF	Multilateral Fund under the Montreal Protocol
MLP	Multilevel Perspective
MoU	Memorandum of Understanding
MS	Member States
MTOE	Million Tons of Oil Equivalent
MW(h)	Megawatt (hours)
NAFTA	North America Free Trade Agreement
NATO	North Atlantic Treaty Organization
NDCs	Nationally Determined Contributions
NEO	New Energy Outlook
NERC	North American Electric Reliability Corporation
NGO	Non-Governmental Organization
NIMBY	Not In My Back Yard
NPS	New Policies Scenario
NREL	National Renewable Energy Laboratory
NSG	Nuclear Suppliers Group
NSS	Nuclear Security Summit
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum-Exporting Countries
OPEX	Operational Expenditures
OTSO	Offshore Transmission System Operator
PACE	Partnership to Advance Clean Energy
PPA	Power Purchase Agreements
PV	Photovoltaic
R&D	Research and Development
RD&D	Research, Development and Demonstration
RES	Renewable Energy Sources
RPO	Renewable Purchase Obligations
SCADA	Supervisory Control and Data Acquisition Systems
SMR	Small Modular Reactor
SPR	Strategic Petroleum Reserve
StrEG	Stromeinspeisungsgesetz (Germany)
TAPI	Turkmenistan–Afghanistan–Pakistan–India
TFEU	Lisbon Treaty
TRANSCO	Transmission Company
TSO	Transmission System Operator
TW(h)	Terawatt(hours)
UAE	United Arab Emirates
UHVDC	Ultra-High-Voltage Direct Current
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States

WB	World Bank
WEO	World Energy Outlook
WTO	World Trade Organization
WVS	World Values Survey
WWF	World Wildlife Fund
WWII	World War II

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Chapter 1
The Geopolitics of Renewables—An Introduction and Expectations

Daniel Scholten

1.1 Introduction

Renewable energy represents a game changer for interstate energy relations. Its geographic and technical characteristics are fundamentally different from those of coal, oil, and natural gas. Renewable energy sources are abundant and intermittent; renewable energy production lends itself more to decentral generation and involves rare earth materials in clean tech equipment; their distribution, finally, is mostly electric in nature and involves stringent managerial conditions and long-distance losses. These stand in clear contrast to the geographically fixed and finite nature of fossil fuel resources, their general reliance on large centralized production and processing installations, and their ease of storage and transportation as solids, liquids, or gases around the globe. As the characteristics of fossil fuels have shaped contemporary energy-related patterns of cooperation and conflict among countries, the question rises how the transition towards renewables will reshape strategic realities and policy considerations of energy producers, consumers, and transit countries and relations between them. Moreover, who are the likely winners and losers?

Energy geopolitics is generally associated with fossil fuels, especially oil and natural gas. The focus on fossil fuels stems from their dominance in the global energy mix. Coal, oil, and natural gas combined account for 86% of global energy consumption in 2014 (BP 2015). To meet demand, 2014 knew a staggering production of 32.365 billion barrels of oil, 3460.6 billion cubic meters of gas, and 3933.5 million tons oil equivalent of coal (BP 2015). By comparison, nuclear energy (4%), hydropower (7%), and various forms of renewable energy (3%) clearly make up 'the rest' of global energy consumption in 2014 (BP 2015).

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Moreover, even though reserves are depleting, global demand is still growing for fossil fuels in general. In short, the importance of coal, oil, and natural gas in global trade can hardly be overstated nor can their key role in fueling industrial processes and modern economies be denied.

The special preoccupation of energy geopolitics with oil and natural gas can be attributed to the specific geographic and technical characteristics of oil and gas systems that have shaped the particular (politicized) nature of contemporary interstate energy relations.[1] Oil and natural gas reserves are finite and geographically concentrated.[2] Energy production and refinement takes place in large, i.e. high capacity, centralized facilities (that are dependent on constant input but produce a stable output) near oil and gas fields or in facilities closer to demand centers; business models are dominated by economies of scale, making national and multinational companies the key players. The physical infrastructure is characterized by many transport modalities (pipelines, tankers, rail, road) and efficient storage options (depots, cylinders), making for an easily manageable whole of physically separable components. Moreover, oil and gas are well-suited for long-distance (global) trade as there is negligible loss of energy content. Current strategic realities and policy considerations are clearly shaped by these characteristics. Energy geopolitics is generally regarded to revolve around depleting and geographically concentrated oil and gas reserves in politically unstable countries in the Middle East and North-Africa (MENA) and Central Asia and Caspian Region (CACR). The unequal geographic distribution creates a clear separation between net-exporters and net-importers, setting up oligopolistic markets where producers such as Russia and the OPEC countries hold considerable market power and try to keep prices up and where consumers follow policies of diversification of source, origin, and route to secure access to (cheap) resources. Naval trade routes and pipeline politics play a crucial role for net-importers such as the US, EU, China, Japan, and India in securing supply from across the globe as do strategic reserves to limit vulnerability to transport bottlenecks and the effects of accidents and cut-offs. The oligopolistic setting is somewhat tempered due to net-exporters' economic dependence on oil and gas rents and net-importers' dominance in global political affairs and their sheer market size. The energy game is furthermore characterized by

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[1] It is safe to state in this regard that since the Industrial Revolution the particular constellation of the geographic location of coal, oil, and natural gas reserves, the nature of energy demand, and infrastructure technologies has formed the specific trade patterns of regional and global energy markets and shaped a complex web of relations among energy producing, consuming, and transit states and a host of non-state actors (Amineh 2007).

[2] Oil and natural gas are considerably more concentrated than coal. About 61,5% of proved oil reserves originate in just five countries ((Venezuela, Saudi Arabia, Canada, Iran, and Iraq) and about 58% of proved natural gas reserves is located in merely four countries (Russia, Iran, Qatar and Turkmenistan) (BP 2016, 6 and 20). While 57% of global coal reserves can be found in three countries (the US, China, and Russia) (BP 2015; 2016), there are far more reserves to last us into the future and a more even distribution beyond these countries.

big (multi)national oil and gas companies that hold key generation and distribution know-how and assets (refineries, storage hubs, harbor facilities, etc.), environmental degradation and harmful emissions due to fossil fuel use, and the concept of peak oil. Until recently, oil companies and net-exporters were planning to exploit ever more unconventional oil and gas deposits in the assurance that prices would slowly rise over time due to growing demand and decreasing stocks. In all, energy relations are viewed as zero-sum and inherently conflict prone.

The increasing use of renewable energy sources slowly but surely erodes the dominance of fossil fuels. Whether due to climate change concerns, stock depletion, or for reasons of diversification away from oil and gas, renewable energy use is growing, generally outpacing fossil fuels (NREL 2008; REN21 2012; Bloomberg 2013) and even our predictions (de Vos and de Jager 2014). Renewables are the fastest growing source with an average ratio of 2.6%/year, followed by nuclear (2.3%/year) and fossil fuels (lower than 2% a year). Moreover, investment is also shifting towards lower-carbon sources of energy (IEA 2016). Nevertheless, due to a general increase in global energy demand, the share of fossil fuels is still expected to cover 78% of world energy consumption in 2040, with renewables and nuclear sharing the remaining 22% (EIA 2016, 9). Essentially, the share of modern renewables in the global energy mix is expected to grow from around 11–13% in 2012 to 15–18% in 2040 (IEA 2013; EIA 2013) with nuclear accounting for the rest. The share of renewables in electricity production is expected to grow faster, from 22% modern renewables in 2012 to 29% in 2040 (EIA 2016, Chap. 5).

This transition towards renewable energy represents a game changer for interstate energy relations. The geographic and technical characteristics of renewable energy systems differ greatly from those of coal, oil, and natural gas systems. Renewable energy sources are abundant and intermittent; renewable energy production lends itself more to decentral generation and involves rare earth materials in clean tech equipment; their distribution, finally, is mostly electric in nature and involves stringent managerial conditions and long-distance losses. As the share of renewables in the global energy mix grows, so too will their characteristics increasingly shape energy geopolitics.

The geographical and technical characteristics of renewable energy systems have given rise to a number of expectations[3] regarding the nature of future interstate energy relations (Scholten and Bosman 2013, 2016). First, a shift from oligopolistic to more competitive markets due to the abundance of renewable energy sources. As most countries possess some form of renewable energy, countries essentially face a make-or-buy decision and are no longer completely dependent on overseas reserves. While political entanglements in the MENA and CACR are likely to become less, access to geographically bound renewables and availability at the right time due to renewables' intermittent nature are set to become new concerns. Second, we may expect an increasingly decentralized nature of energy production by and for a more varied set of local actors, enabling new business models and local

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[3] These are discussed in more detail in Sect. 1.4.

empowerment. Third, increasing competition for rare earth materials and clean tech know-how between countries that aspire to be industrial leaders in renewable generation technology is highly likely. Another expectation is the electrification of energy systems, as electricity is the energy carrier of most renewables. The likely implications of this are a regionalization of energy relations because of long-distance losses and a strategic emphasis on continuity of service supply instead of commodity supply due to renewables' abundance and stringent managerial conditions.

Contemporary developments show some indication that we are heading in the direction of these expectations. We can already observe, for example, that net-importers use domestically available renewables as sources of diversification, eroding the market power of oil and gas exporters, who for their part worry about stranded assets. We can also see how countries like the US, Germany, and China compete for industrial leadership in renewable energy generation technologies and that they investigate access to rare earth materials as a potential bottleneck and liability. Another visible development is plans for supergrids like Desertec, the North Sea offshore wind grid, or North-American interconnection. China has even spoken about a global electricity grid in this regard. Their implications for energy relations are unclear, however. Perhaps the best indication stems from Germany's Energiewende, where European interconnection allows intermittent renewables' negative effects (price fluctuations and network congestion) to spill across borders, but also provides the benefits from trade and the possibility to level out regional peak production across the continent. Locally, the system integration of renewable energy production by households, companies, and cooperatives and microgrid options are changing networks and markets from the bottom up. They challenge established operational practices of utilities and business models of big power companies, but also offer countries new possibilities to secure energy supply and develop regions. In all, great powers such as the US, EU, China, Russia, Japan, India, and OPEC countries are clearly strategizing to reap the benefits and mitigate the drawbacks of a transition to renewable energy. New institutions seem necessary to guide potential conflict towards mutually beneficial cooperation.

Despite such developments, much remains uncertain. It is unclear, for example, how developments like great power rivalry between the US and China or the EU and Russia and technical innovations in batteries or ICT will influence the speed and direction of the energy transition and nature of energy systems. Moreover, renewables will be utilized in very different socio-cultural and political-institutional environments. Such, and other, contextual factors might influence interstate energy relations just as much if not more than renewables' characteristics. We would also do well to remember at this point that coal, oil, and natural gas are not disappearing anytime soon; fossil fuels will occupy a larger share in the global energy mix well into this century (EIA 2016). It is even questionable whether renewable sources are sufficient to power the globe at all, given their spatial and material requirements. Hence, despite the fundamental changes that renewables are expected to bring to energy systems, energy geopolitics will be dominated by fossil fuels in the coming decades. It might well be that, for the time being, expectations about the energy transition are going to affect energy geopolitics more than the actual use of renewable energy. The perception of inevitable things to come, like stranded assets or plans for supergrids, may influence country strategy more than any tangible development.

In sum, it is clear that the energy transition is more than a mere change in the energy mix. While renewables offer solutions to fossil fuel related concerns such as import-dependence, climate change, and transport bottlenecks, they create a range of new challenges for interstate energy relations. The question is more how exactly renewable energy systems impact infrastructure topology and operations, business models and energy markets, trade patterns and welfare, and strategic realities and policy considerations of producer, consumer, and transit countries and relations between them. Moreover, which countries are the likely 'winners' and 'losers' of a transition to renewable energy and how can they strategize to reap the benefits and mitigate the drawbacks? What is necessary is a comprehensive study of renewables' impact on interstate energy relations in general and for specific countries and regions in particular, supported by a framework that can help understand the relationship between renewable's characteristics and energy geopolitics.

This volume explores the geopolitics of renewables: the implications for interstate energy relations of a transition towards renewable energy. More specifically, it investigates how the geographic and technical characteristics of renewable energy systems (re)shape strategic realities and policy considerations of producer, consumer, and transit countries and energy-related patterns of cooperation and conflict between them. Focus is on contemporary developments and how they may shape the coming decades. The objective is to establish a comprehensive overview and understanding of the emerging energy game, one that puts the topic on the map and provides practical illustrations of the changes renewables bring to energy geopolitics and specific countries. To this end, a novel analytical framework is introduced that moves from geography and technology to economics and politics and developments are studied on three levels of analysis:

- The emerging global energy game; winners and losers
- Regional and bilateral energy relations of established and rising powers
- Infrastructure developments and governance responses

The Geopolitics of Renewables is the first volume to specifically explore the geopolitical implications of a transition to renewable energy; a novel topic that has gone under the radar for too long. It should certainly not be seen as the definitive work on the subject. Quite the contrary, it represents a first inroad to a new topic, one that scopes a new phenomenon and acts as a teaser for future works. It is intended for both academics and practitioners. To start, readers are provided with the first literature review of the field of geopolitics of renewables and a novel analytical framework that breaks down a complex topic into manageable pieces and structures the discussion. This not only enhances our understanding of the relationship between renewables' characteristics and interstate energy relations, it also makes the study more accessible and tangible to readers, ideal for putting the topic on the map and emphasizing the need to research and debate this topic. Second, the volume offers a comprehensive overview of global, regional, and infrastructure challenges facing countries and regions such as the US, EU, China, India, Russia, and OPEC in the emerging energy game and illustrates these with practical examples. Such an understanding may be able to assist decision makers to oversee the geopolitical implications of a growing use of renewable energy sources, allowing them to make informed decisions on securing an affordable renewable energy supply in the future.

The remainder of this chapter presents a literature review that maps the new field of the geopolitics of renewables, combining insights from international relations, (energy) geopolitics, and energy security on the one hand and renewable energy technology, energy economics, energy transitions, and energy policy on the other to clarify key concepts and their relation (Sect. 1.2). It then constructs an analytical framework that revolves around the relationship between the geographic and technical characteristics of renewable energy systems as the independent variable and interstate energy relations as the dependent variable (Sect. 1.3). Section 1.4 presents expectations with regard to the geopolitics of renewables. Section 1.5, finally, details the structure of the volume. Please note that in these endeavors this chapter builds directly upon an earlier paper and article by Scholten and Bosman (2013, 2016).

1.2 A Field in the Making

The geopolitics of renewables has only recently become a matter of academic investigation. International Relations scholars have almost exclusively focused on oil and gas when studying energy geopolitics or security whereas renewable energy experts have targeted the development and market diffusion of new technologies. As a result, while the strategic consequences of the depleting and geographically concentrated oil and natural gas reserves are well-documented, there exists a great deal of uncertainty regarding the international political implications of renewable energy systems. In other words, despite the abundant literature on energy security and energy geopolitics on the one hand and renewable energy technologies and transitions to sustainability on the other, the study of how the geographic and technical characteristics of renewable energy systems shape interstate energy relations is still in its infancy. As a consequence, a common framework with which to explore the issue is lacking and existing studies offer only fragmented, partial insights. Nevertheless, due to sufficient source material, the necessary concepts and ideas to progress are present and we are able to identify the most likely implications of renewables for interstate energy relations.

According to the International Energy Agency (IEA) “[r]enewable energy is energy that is derived from natural processes that are replenished constantly [in a natural way and includes such sources as] solar, wind, biomass, geothermal, hydropower, ocean resources [tidal and wave], and biofuels, electricity and hydrogen derived from those renewable resources” (IEA 2004, 12). Renewable energy sources hence stand in direct contrast to exhaustive fossil fuel sources such as coal, oil, and natural gas, whose deposits are essentially finite. The introduction of renewables in the energy mix is more than a mere shift in sources; it entails accompanying changes in infrastructure[4] operations, energy markets, and sector regulation as well. A renewable energy system, then, should not only refer to the actual sources, but also the infrastructure technologies such as generation and distribution assets, storage means, and control facilities necessary to bring them to market. Deudney (1989) already referred to the close relationship between the accessibility of energy sources and technological possibilities of extracting and capturing energy as the 'geotechnical ensemble'. We only add the infrastructure component. Such notions are also more in line with the modern perception of energy infrastructures as complex adaptive socio-technical systems (Ewertsson and Ingelstam 2004; Hughes 1983; Kroes et al. 2006; Kaijser 2005; Nelson 1994; Geels 2004; Weijnen and Bouwmans 2006; Scholten 2013; Scholten and Künneke 2016).[5]

The literature on renewables is dominated on the one hand by engineering studies on their technical potential, their capacity to power the future, and scenarios on their role in future energy systems (see e.g. Resch et al. 2008; Ellabban et al. 2014; Boyle 2004; de Vries et al. 2007; Moriarty and Honnery 2016; Fortes et al. 2015; IEA 2013, 2015, 2016; Ecofys 2008). Economists and social scientists, on the other hand, focus on the transition process, the challenges associated with renewables' market and system integration, the economic modeling of their diffusion, and the policy instruments that may be used to promote them (see e.g. Verbong and Geels 2007; Verbong and Loorbach 2013; Grin et al. 2010; Abrell and Rausch 2016; Bouffard and Kirschen 2008; Schleicher-Tappeser 2012; Duan et al. 2014; Meade and Islam 2015; Haas et al. 2004; Menanteau et al. 2003). This focus on renewable energy technologies and transitions to sustainability goes at the expense of international, geographic, or geopolitical aspects. Only occasionally is renewables' spatial dimension discussed (Bridge et al. 2013; Stoeglehner et al. 2011) or is global energy governance addressed (Van de Graaf 2013; Lesage et al. 2010). Nevertheless, we may draw upon these works to understand how renewables affect system operations (e.g. generation and distribution assets, storage, managerial requirements) and energy markets (e.g. prices, business models, investment

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[4] We define infrastructures as "the framework of interdependent networks and systems comprising identifiable industries, institutions (including people and procedures), and distribution capabilities that provide a reliable flow of products and services […]" (Rinaldi et al. 2001, 13, citing the US Critical Infrastructure Assurance Office (CIAO)).

[5] Central to this view is that infrastructures are "erected and structured around a certain technical core of physical artifacts [that are] embedded in, sustained by, and interact[ing] with comprehensive socio-historical contexts" (Ewertsson and Ingelstam 2004, 293). The obvious peculiarity of this perspective is that it does not follow an exclusively technical topology of infrastructures but considers the interaction of the integrated physical and social/ organizational networks a crucial element in determining system performance. Focus is on how technologies, actors, and rules mutually influence and continuously reconstitute each other in a co-evolving manner characterized by lock-in and path-dependency. In this light, energy infrastructure performance - commonly measured in terms of availability, affordability, and acceptability (EC 2001)—is the result of interaction between techno-operational characteristics, energy market dynamics, and institutional arrangements.

decisions, regulations). Most importantly, they remind us to focus on renewable energy systems, not just the sources, when thinking about the energy transition.

Geopolitics refers to “politics, especially international relations, as influenced by geographical factors”, usually through politicians that act upon geographic considerations (Oxford online dictionary 2012). The notion of geopolitics, belonging to both Political Geography and International Relations harbors many different interpretations. To Criekemans (2011, 4), for example, geopolitics “investigates the interaction between [political actors] and their surrounding territoriality in its three dimensions: physical-geographical, human-geographical and spatial.” A different classification can be made between the more classical or orthodox geopolitics and that of critical geopolitics (Mahan 1890; Ratzel 1897; Mackinder 1904; Haushofer 1934; Spykman 1944; Kissinger 1994; Brzezinski 1997; Amineh 2003; Agnew 1998; O’Tuathail and Dalby 1998). The former relates mostly to the ‘rivalry between great powers in its geographic dimension’ (akin to the realist school of International Relations). In this struggle for power, land and resources are imperative for the survival of the nation. Famous examples in this light are the ‘scramble for Africa’, Mackinder’s heartland notion, Germany’s quest for Lebensraum, or US containment policy during the Cold War. The latter perceives “Geographic arrangements [as] social constructions that are changeable over time depending on political, economic and technological changes” (Amineh 2003, 24) (akin to liberal and critical theories in International Relations). Next to the traditional focus on hierarchies of power and the access to natural resources, explanatory factors are also found in the global economy (control of trade, production, and finance), political discourse, and the legitimacy of power. Foregoing a lengthy discussion on what geopolitics is, referring rather to Amineh (2003) and Criekemans (2007) for a thorough reading, we follow the simple definition of the Oxford dictionary in this volume, though we narrow it down to interstate *energy* relations.

Most works on energy geopolitics stem from the discipline of International Relations. Considering the economic and strategic importance of energy for the wealth and power of states, international relations scholars have always had a great interest in energy security.[6] A multitude of studies reveal ample examples of how

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[6] The concept of energy security is notably hard to define, but its core dimensions are relatively clear (Winzer 2012; Sovacool and Mukherjee 2011; Chester 2010; Kruyt et al. 2009). At its narrowest, energy security is generally synonymous with security of supply at affordable prices. See for example the World Energy Council (2008, 1): energy security may be defined as “an uninterruptible supply of energy, in terms of quantities required to meet demand at affordable prices.” Such a definition relates to dimensions such as geological availability, political accessibility, economic affordability, and infrastructure resilience (or reliability and robustness). Typical concerns relate to the finite and geographically concentrated nature of oil and gas reserves, policies of diversification of source, origin, and route, price volatility due to political instability in producer countries, and a variety of technical, human, and natural risks to infrastructure. Avoiding dependence and vulnerability are key (Percebois 2003; Gnansounou 2008). Focus is on energy supply continuity (Winzer 2012), encompassing continuity of commodity supply, continuity of service supply, and the political-economic impact of discontinuity. At its broadest, the term also includes dimensions such as environmental sustainability, social acceptability, technology

the topology of oil and gas reserves and accompanying infrastructures affect political decision making in both consumer and producer countries and the nature of interstate energy relations between them (Amineh 2007; Amineh and Guang 2010, 2012; Dannreuther 2010; Correlje and van der Linde 2006; Umbach 2010; Klare 2008; Friedman 2006; Andrews-Speed 2008; Eisen 2011). A famous example is the EU's efforts to secure energy supply in the wake of the Ukrainian crises in 2005–2006 and the pipeline politics that followed it or the more recent Energy Union. Another would be the new great game in Central Asia and the Caucasus or the Indian Ocean (Royal Symposium 2015). Most other works focus on the dealings of major oil companies and the politicized history of oil (Yergin 1991, 2011; Parra 2010) and the resource curse and political economy of energy in producer countries (Auty 1993; Akiner 2004; Humphreys et al. 2007). Considering this attention, it is all the more remarkable that present-day geopolitical and international relations literature has "only barely scratched the surface with regard to exploring the potential geopolitical effects of the transition towards more renewable energy sources" (Criekemans 2011, 4). Only a handful works in this area exist, which are treated below. Indeed, stranded oil and gas assets (Ansar et al. 2013; OECD 2015), the implications of shale gas and tight oil (Ladislaw et al. 2014; Pascual 2015), or the impact of climate change and climate policy on (energy) security and politics (Nuttall and Manz 2008; Chevalier and Geoffron 2013; Overland 2015; Salzman 2016; Streck and Terhalle 2013; Rothkopf 2009) have received considerably more attention from the field. Most of the time, renewables feature in oil and gas dominated (country) energy security accounts as means of diversification and climate change abatement (see e.g. Ölz et al. 2007; Verrastro et al. 2010). Such accounts, however, frequently neglect to give proper attention to energy security challenges specifically raised by renewables or, more fundamentally, how renewables' characteristics change the nature of energy geopolitics from the ground up. Put differently, they do not take the disruptive potential of renewables to redefine energy systems and markets as a point of departure and tend to see the energy transition as a mere shift in the energy mix towards renewables. Nevertheless, the literature harbors a rich set of operationalized notions with which to discuss renewable's impact on interstate energy relations: energy security, dependence and vulnerability,[7] stability of energy prices in global markets, trade patterns, and possibilities for

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development, and regulatory stability (Sovacool and Mukherjee 2011). Typical concerns are local pollution and climate change, public acceptance and equity, sufficient investments in R&D and networks, and policy (making) transparency and commitment respectively. The policy framework with which energy security should be assured is controversial. While some decision makers trust in market instruments for optimising the energy supply mix, others urge for more government intervention arguing that markets fail to ensure adequate and sustained levels of energy security (Constantini et al. 2007; Egenhofer and Legge 2001).

[7] Dependence refers to "the share of national energy consumption which is produced domestically vis-à-vis energy imports" (Gnansounou 2008, 3735). It is closely related to the concept of risk. "The vulnerability of a system is the degree to which that system is unable to cope with selected adverse events." Vulnerability expresses the consequences of energy supply interruptions (Gnansounou 2008, 3735).

diversification (source, origin, or route), etc. These notions seem just as relevant for renewables as they are for fossil fuels when it comes to analyzing geopolitical implications.

Specifying the parts, i.e. renewables and geopolitics, does not automatically describe what the whole, i.e. the geopolitics of renewables, is all about. The novelty of the topic also does not help in this regard; there exists no readily available description of the field, what its focus is or should be and what is included or excluded. At this moment, the field merely combines all kinds of insights from the source material above to make due, but lacks a consistent and clearly defined research trajectory. This leaves it to us to define what we mean by it. Doing so, and following our earlier definition of renewable energy and geopolitics, this volume takes the perspective that the study or field of the geopolitics of renewables is at its very essence about how the geographic and technical characteristics of renewable energy systems shape interstate energy relations, i.e. the strategic realities and policy considerations of producer, consumer, and transit countries and energy-related patterns of cooperation and conflict between them. We consider investigating this core relationship key for understanding contemporary developments and estimating the impact of renewables on interstate energy relations in the coming decades.

Five additional remarks on this perspective are in order at this point. First, there is an analytical distinction between implications for interstate energy relations stemming specifically from renewables' geographic and technical characteristics and those stemming from the transition to renewables in general. For example, while the abundance of renewable sources would qualify for a geopolitical analysis as it represents a clear geotechnical feature, possibilities for industrial leadership in clean tech or the effects of renewables on oil demand are not. This creates a dilemma for this volume. On the one hand, we do not want to miss out on important implications of a transition to renewables, i.e. sacrifice practical relevance. On the other hand, academic rigor dictates a clear focus on the geographic and technical characteristics if we want to do justice to the term *geo*politics. To get the best of both worlds, this volume shows all relevant implications of a transition to renewable energy, but acknowledges the analytical difference and has special interest in the core relationship. In other words, while it follows the strict interpretation of 'geopolitics of renewables', it does a concession to the more general usage of the term. Second, the geopolitics of renewables is heavily intertwined with the geopolitics of fossil fuels. While we may analytically separate the geopolitics of renewables from those of fossil fuels,[8] the fact that both fossil fuels and renewable energy will coexist in the energy mix for the foreseeable future implies that any

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[8] In principle, one could investigate the geopolitics of renewables as isolated from that of fossil fuels. In the past, energy geopolitics has been synonymous with that of fossil fuels and was studied as isolated from renewables. In the far future, energy geopolitics may be synonymous with the geopolitics of renewables, due to lack of use of fossil fuels. It is only now, in the meantime, that the geopolitics of renewables is essentially about how the increasing use of renewables affects the current, fossil fuel dominated, energy game.

(practically relevant) understanding of the geopolitics of renewables is in essence about how the energy transition affects fossil fuel dominated interstate energy relations. Third, the focus on interstate energy relations does by no means imply that non-state actors are irrelevant. Considering the importance of multinational oil and gas companies in the exploration, production, transportation, and retail of energy thus far, they cannot and should not be excluded. Moreover, renewable energy opens possibilities for new business models and empowers new actors. Fourth, the focus on interstate energy relations does not automatically exclude a necessity to investigate national political implications of renewables. Quite the contrary, domestic opportunities for more centralized and decentralized renewable energy options and powerful industrial and consumer lobbies are a key factor in determining energy foreign policy of countries. Finally, the obvious drawback of this perspective is that it excludes the opposite, i.e. studying how interstate energy relations influence the development of renewable energy. The course and speed of the transition or the specific technologies developed are not immune to other developments in global politics in general and energy politics in particular. For example, Fischhendler et al. (2016) noted how renewable energy projects are used as political tools between the Israeli and Palestinians.

First attempts to bring the worlds of geopolitics and renewables together are steadily emerging. Criekemans (2011), for example, noting the different locations for efficient generation of renewable energy vis-à-vis the location of fossil fuel reserves today, speculates about the effects on the position of major powers and their ability to utilize the transition to renewables to move up the global hierarchy. Following up, Scholten and Bosman (2013, 2016) explored the general principles or determinants that shape the nature of interstate renewable energy relations, i.e. the play of the game between producer, transit, and consumer countries and the strategic realities these countries face, in a thought experiment where the world would source its energy needs 100% from renewables. In similar attempts, Johansson (2013) explores the energy security implications of renewable energy while Casertano (2012) points to new challenges as a result of renewable and climate policies. Others investigated the effect of the energy transition in one country on its energy security and neighbouring countries, e.g. Germany's Energiewende (Bosman 2012; Bruninx et al. 2013; Strunz and Gawel 2016), the role of renewables in foreign policy (Dreyer 2013), the geo-economic implications for EU energy policy of a shifting topology of generation and infrastructure capacity as a result of renewables (Scholten et al. 2014) or the impact of EU internal decarbonisation policies (climate and energy) on its external relations with energy partners such as Norway, Russia, the Caspian region, and to a lesser extent the MENA region (Sweijs et al. 2014; Dupont and Oberthür 2015). Again others note more broadly the impact of the clean energy transition on international oil companies and oil producing countries (Haug 2011; van de Graaf and Verbruggen 2015), see possibilities for mutually beneficial energy cooperation among countries (Gullberg 2013; Gullberg et al. 2014), or have studied the risks and rewards of renewable energy (Smith Stegen 2014). Specific attention has also been paid to the conflict potential of rare earth materials in international energy dependencies (Buijs and Sievers 2011; de Ridder 2013) and security threats to renewable energy infrastructure from sabotage by terrorists (Smith Stegen et al. 2012). More recently, Stang (2016) and Huebner (no date, likely 2016) see the political weight of renewables growing in an energy geopolitical setting that is increasingly stuck between fossil fuels and renewables. They find clear winners in those countries with high energy consumption and few own resources like India, China, Mexico, Brazil, and Europe and clear losers in the form of leading oil and gas exporters whose leverage decreases as energy types and suppliers diversify and the need for long-distance transport of fuels diminishes due to decentral generation and smart grids. Hache (2016) and Paltsev (2016), in contrast, point to new dependencies replacing the old and to how the transition to renewables increases complexity of energy geopolitics due to a more heterogeneous set of technologies and actors involved, which makes predicting winner and losers highly uncertain. Most recently, the need to scope the topic and provide options for further analysis stood central in a paper resulting from a high-level workshop on the geopolitics of renewable energy in Berlin, Germany (O'Sullivan et al. 2017).

In all, while these early studies provide good examples of how renewables affect interstate energy relations, they present a fragmented picture of the issue at best.[9] As a consequence, there exist quite some ideas where renewables' geographic and technical characteristics lead us, but a framework with which to systematically approach and investigate the geopolitics of renewables is lacking. The dependent and independent variables in these studies are different, the operationalization of core concepts differs, and more often than not is an explicit investigation into the core relationship between the geographic and technical dimension of renewable energy systems and its geopolitical implications absent. As a result, there is no comprehensive overview and understanding of the geopolitics of renewables. Nevertheless, we possess the necessary concepts and ideas to frame the issue thanks to abundant source material on renewable energy systems and international (energy) relations. In turn, Sect. 1.3 develops a framework of analysis to study the relationship between the geographic and technical characteristics of renewable energy systems and interstate energy relations, while Sect. 1.4 provides a look at renewables' likely implications for energy geopolitics.

1.3 A Framework of Analysis

The study of the geopolitics of renewables is at its very essence about how the geographic and technical characteristics of renewable energy systems (independent variable) shape interstate energy relations (dependent variable). To systematically

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[9] We currently have hardly any academic research on how the geographic abundance of renewable sources will affect energy system topology and cross-border energy flows, or how decentralized generation and the generally electric nature of renewable energy transportation will pose new challenges to energy trade and security.

approach and investigate the topic, we proceed by operationalizing the core concepts under study, building upon the literature review in Sect. 1.2, and discussing how their relationship can be established in a complex, dynamic setting where many contextual factors impact it. The aim is to break down a complex topic into distinguishable and manageable pieces and in this way structure a discussion on the subject. This aids the understanding of the relationship between renewables and energy geopolitics and makes it more accessible to readers. In doing so, a framework of analysis is created. Afterwards, we reflect on the use of the framework in this volume and identify various levels of analysis on which the core relationship is investigated. For the exact methods and data gathering we refer to the various chapters.

In our endeavour, the independent variable comprises the geographic and technical characteristics of renewable energy systems. This relates to sources, generation, and distribution.[10] For sources, it is of interest to look at their geographic location, their stability/variability, and their overall potential in meeting demand. Examples are efficient locations for solar farms or the intermittency of wind. Generation relates to site location, the technology used and its central-decentral nature, and material requirements. Examples are possibilities for local generation vs. large facilities or the availability of rare materials. Distribution can be operationalized as network technology and topology, operating systems, and storage means. The nature of transportation (as solid, liquid, gas, electric) and the managerial requirements to bring renewable energy to consumers like grid reinforcements and smart control systems feature here. Some of these geographic and technical characteristics are more fixed than others. The prime locations of renewable energy production such as the location and intensity of solar radiation, wind speeds, waves, geothermal hotspots, etc. are weather and geology dependent and highly unlikely to change over the course of centuries (assuming that climate change will not alter this). Distribution networks, in contrast, are actually more flexible despite their fixed appearance: electricity wires, transformer stations, storage facilities, interconnectors, and managerial control may relocate based on political decisions, costly as it may be. In the end, it is of course especially interesting how these characteristics differ from those of fossil fuel based systems and how this changes infrastructure topology and operations.

The dependent variable comprises interstate energy relations. This relates to the strategic realities and policy considerations of producer, consumer, and transit countries and energy-related patterns of cooperation and conflict between them. Strategic realities can be assessed by looking at countries' energy security

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[10] The consumption of energy is left out intentionally. While the location of demand, the type of appliances, and the nature of energy use are relevant for energy geopolitics, our focus is here explicitly on renewable energy system characteristics. Investigating the implications of changes in energy demand for interstate energy relations, for example a demand shift from the global North to the global South, would in fact entail an entirely separate research effort.

situation[11]—its various dimensions,[12] components, and indicators[13] (Sovacool and Mukherjee 2011; Winzer 2012; Chester 2010; Kruyt et al. 2009)—and the means available to carry out particular strategies, i.e. a country's political and economic capabilities in relation to those of other countries. How does the energy transition affect the secure supply of energy at affordable prices? What new dependencies and vulnerabilities arise? What leverage can be used to pursue energy targets? Policy considerations can be analyzed by looking at country interests (policy goals such as availability and affordability), available policy options, and possible strategies to pursue these options. What policy responses are available to safeguard energy security? How can countries strategize to reap the benefits and mitigate the drawbacks? We assume in this regard that consumer countries are concerned about security of supply and desire stable and affordable energy prices, that producers want to maximize energy revenues to fuel their economy and desire security of demand, and that transit countries are interested in retaining their position in the infrastructure in order to extract a fair rate for their services and to create some political leverage for themselves. Energy-related patterns of cooperation and conflict can be studied by looking at historical accounts of energy relations between countries and the changes that renewable energy have brought to these relations. Specific interest may go to different forms of cooperation (long-term or short-term, via markets or bilateral) and conflict (diplomatic, legal-institutional, political and economic pressure and sanctions, military intervention). Do renewables lead to more or less conflictuous interstate energy relations, i.e. more or less geopolitical tensions, and what can be done, through policy or institutions, to remedy tensions and steer towards cooperation? The question is not only what do we see, however, but also in how far observations are a consequence of the geographic and technical characteristics of renewable energy systems.

The relationship between the dependent and independent variables may not be immediately apparent. First, it can prove a big step from geography to politics, making it hard to connect the dots. Second, numerous contextual and case-specific factors also shape interstate energy relations next to the geographic and technical characteristics of renewable energy systems, blurring what geopolitical implications are caused by renewables and which are not.

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[11] Typical things to investigate, among many others, would be national capacities for (renewable) energy generation, import dependence, access to rare materials, know-how of key technologies, manufacturing capability, infrastructure and storage options, decision rights on cross-border flows, etc.

[12] We distinguished between geological availability, political accessibility, economic affordability, infrastructure resilience, environmental sustainability, social accessibility, technology development, and regulatory stability as dimensions in this light.

[13] Sovacool and Mukherjee (2011), for example, distinguish between 5 energy security dimensions, divided into 20 components, and a staggering 320 simple and 52 complex indicators. Winzer (2012), in contrast, identifies various sourcesof risk (human, technical, natural), four clusters of impact measurement (continuity of commodity supply, service supply, the economy and environmental impacts), and six severity filters to distinguish levels of impact, i.e. continuity interruption.

To address the former, it can be beneficial to investigate the influence of renewables' characteristics on business models, energy markets, trade patterns, and welfare effects as an intermediary step. As we saw earlier, both the market integration of renewables as well as the strongly interwoven nature of energy markets and strategic dependencies of countries are well described in the literature. The economic 'detour' may therefore be convenient for linking geography and politics and in this way enhance our understanding of renewables' impact on the energy game. As an additional benefit, breaking the relationship up by adding an intermediary component provides additional insights and further structures our reasoning. To investigate the economic implications of the technical and geographical characteristics of renewable energy systems, we may borrow from works on business models, micro and macro-economics, and international economics.

First, we may study what new business models like decentral generation or flexibility trading look like in terms of value proposition, creation, and capture, or in somewhat different terms where the innovation lies, how companies or other actors are organized, and how revenue is generated.

Second, we may analyze how characteristics of renewable energy systems affect the relevant market and market structure. The relevant market refers to product characteristics, time constraints (storage possibilities), and market scope (geographic size and consumer groups). For example, renewable sources vary in terms of intermittency and markets may be local, national, regional/continental, or global. The notion of technical system boundaries strongly relates to the relevant market as they enable and constrain market functioning. For example, the ramp-up/down time of nuclear power plants as compared to combined cycle natural gas turbines impacts their position in the merit order and their functioning in energy markets.[14] Market structure refers to the number of producers and consumers (many, few, single), barriers to entry/exit, and the nature of the good (homogenous or heterogeneous, substitutability). Though not usually included, price stability may also be included here as an important market feature considering the intermittent nature of some renewables. The key logic here is a rather familiar one: do we face a buyer's or seller's market? Like with any market, the presence of many producers, consumers, and transit possibilities, results in a competitive market, and the energy source or carrier may be considered a commodity; the more monopolistic features on the consumer or producer end or bottlenecks in transport, the more the energy source or carrier becomes politicized, is considered a strategic good, and may be expected to lead to geopolitical tensions.

Third, it is of interest to investigate changes in trade patterns by looking at historical and new trade flows, shifts in import and export ratios, interconnectivity

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[14] Different energy production technologies imply various capex and opex trade-offs. There is hence no uniform cost-curve to describe the economics of power plants. Network capacity is another factor that seriously impacts how much energy may be 'traded' between producers and consumers at a given point in time. Combined with demand patterns, these operational considerations have already given rise to a variety of energy markets: day ahead spot markets, long-term bilateral contracts, balancing markets, etc.

between countries, and trade creation and diversion. What new trade relations are emerging between countries and which old ones are terminated in the transition to renewable energy?

Finally, it is beneficial to look at the overall welfare implications of renewables, in terms of GDP (per capita) growth, allocative efficiency, and distribution of costs and benefits. Allocative efficiency relates here to average costs and energy prices, profit margins, and sufficient investments and innovation. The distribution of costs and benefits relates to equity considerations (which societal groups benefit from renewables and which do not), where economic activity and employment are located, and where and how national revenues are generated and on what they are spent.

To address the latter, we need to establish whether a specific change in interstate energy relations is caused by the geographic and technical characteristics of renewable energy systems or by contextual and case-specific factors. Numerous technological, operational, economic, environmental, social, and political developments can affect how renewables' impact on interstate energy relations takes form. For example, climate change and local pollution, innovations in electricity generation and storage, economic growth and globalization, historical interstate relations and great power rivalry, public support and increasing urbanization, financial markets, and national institutional arrangements all influence the way in which renewables affect energy markets and politics. Indeed, energy is but one of many aspects of international relations. These contextual ramifications within which our core relationship is embedded have to be taken into account when making approximations of renewables' geopolitical impact. Hence, whilst investigating how the geographic and technological characteristics of renewable energy systems affect interstate energy relations we need to keep a close eye on how contextual factors influence this reasoning. Only if we are able to separate the context from the geotechnical drivers, can we establish an understanding of contemporary geopolitics of renewables and their likely future implications.

Combining these considerations, we arrive at a framework of analysis that rests on four steps (see Fig. 1.1). The first step charts the implications for infrastructure topology and operations of the geographic and technical characteristics of renewable energy systems. The second investigates how renewables reshape business models, energy markets, trade patterns, and welfare effects within and among countries. The third step studies the strategic realities producer, consumer, and transit countries face in the emerging energy game, the policy responses available to safeguard their energy security, and their effect on established patterns of energy-related cooperation and conflict. Finally, the last step links the previous steps together and reflects on the relationship under study in light of broader contextual developments.

The objective of this volume is to provide a comprehensive overview *and* understanding of the geopolitics of renewables. To do justice to this dual purpose, the introductory and concluding chapters provide a more analytical contribution whereas Chaps. 2–11 focus on contemporary developments and how they may shape the coming decades. This introductory chapter puts emphasis on the (different) geographic and technical characteristics of renewables and the expectations they raise for interstate energy relations (see next section). The independent variable

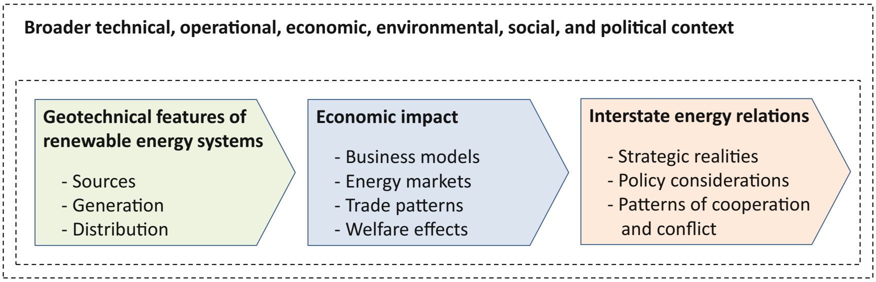

Fig. 1.1 Framework of analysis—the core relationship and its context

hence leads the narrative. Chapters 2–11 showcase the various ways in which the transition towards renewable energy is reshaping energy systems, markets, and politics. The narrative focuses on providing an overview of current developments, country experiences and intentions, and their strategic implications regarding the dependent variable. The concluding chapter summarizes the empirical chapters and reflects on the relationship under study, essentially linking the independent and dependent variable. This highlights what we can already observe from our expectations for energy geopolitics. In this set-up, the analytical framework is used to structure our expectations about and understanding of the geopolitics of renewables in the introduction and conclusion respectively. It is *not* intended for rigid application throughout the empirical chapters of the volume. Rather, it serves as a source of operationalization of the core relationship's main concepts and as inspiration for structuring thinking about the geopolitics of renewables.

To achieve a *comprehensive* overview, we need to do justice to the diverse ways in which renewables affect interstate energy relations. To this end, the core relationship is investigated on three levels of analysis: a) the emerging global energy game, winners and losers; b) regional and bilateral energy relations of established and rising powers; and c) infrastructure developments and governance responses. The global level focuses on the key developments that frame the emerging energy game among great powers from a geopolitical perspective. It offers insights into how the energy transition acts like a force of 'creative destruction' that creates new winners and losers in global energy markets and that blurs the distinction between net-importing and net-exporting countries. The second part offers a country specific perspective by zooming in on how the US, Germany, China, and India[15] approach,

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[15] We limit ourselves purposefully to this selection of countries. While there are more big players in global energy, e.g. Japan, Russia, Brazil, Saudi-Arabia, etc., the purpose of the volume is to showcase the most important changes that renewables bring to energy geopolitics, not to be exhaustive in terms of country scope. We did, however, want to include a distinction between established and rising powers in the energy sector to link the countries to the processes of creative destruction at the global level; how can countries utilize the transition to renewable energy to move up in the global hierarchy or to cement their position? Moreover, as Chap. 4 already focuses on

experience, and handle the energy transition. It highlights what these countries perceive to be their main issues, the opportunities and challenges for these countries' regional and bilateral energy relations, and the strategies they may employ to reap the benefits and mitigate the drawbacks of the energy transition. The infrastructure level discusses how national energy policy is pressured from below and above by decentral generation and microgrids on the one hand and plans for centralized facilities and supergrids on the other. Domestic capacity for more centralized and decentralized renewable energy systems, the simultaneous development of microgrids and supergrids, and the rise of new local and supranational actors harbor the potential to revolutionize energy systems and markets, challenge or support vested interests, and require novel institutional responses. Combined, these three levels capture to the different arenas through which renewables influence interstate energy relations: global energy markets, direct country relations, and infrastructure developments. They also provide a clear separation between more structural changes that affect global energy markets from the country specific strategizing regarding their energy relations within that setting, where countries' range of possibilities is also influenced by changes in physical infrastructure.[16]

It is important to note that our treatment of the geopolitics of renewables is partly about what we already observe and partly about looking forward. Discussions of contemporary developments obviously differ from those that elaborate on the likely geopolitical implications of renewables in the coming decades. The former focus on factual, historical accounts of the core relationship under study within its wider context, with measurable indicators supporting claims of causality. Investigations of the likely future political implications of renewables, in contrast, utilize a number of assumptions and scenarios to support the argumentation of where trends and developments are heading. The analytical framework suits both purposes. It can be used to structure the analysis and assessment of past and contemporary developments (see concluding chapter) and can be translated into a forward-looking exercise as in the next section.

1.4 Expectations

The geographic and technical characteristics of renewable energy systems are different from those of fossil fuels. Looking at renewables' abundant and intermittent sources, their possibilities for decentral generation and reliance on rare earth

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current net-exporters, preference was given to net-importers for part II. This way we avoid unnecessary duplication whilst showing divergences in country approaches to renewable energy.

[16] This is actually similar to the way Geels (2004) writes about the landscape and niche level influencing the regime undergoing a transition. The structural global level creates the larger market setting within which countries trade and the infrastructure level captures those developments that reframe the way energy can be physically moved between countries. This leaves the countries' bilateral- regional relations as the level where policy makers strategize to secure affordable energy given certain global market and infrastructural developments.

materials, and their generally electric nature of transportation, we may infer the likely implications for interstate energy relations. Four sets of expectations stand out in this regard.

The first set of expectations relates to a shift from oligopolistic to more competitive markets. Fossil fuels (coal, oil, and gas) are finite and depleting resources whose reserves are geographically concentrated. Some countries possess them while others do not. Consequently, we see an oligopolistic market where a relatively few well-endowed net-exporters dominate global energy markets and where consumers struggle to get access to these resources and/or try to diversify away from them via source, origin, or route, or hedge using strategic reserves. This game is often perceived as inherently zero-sum. Renewable energy, in contrast, is abundant and relatively evenly spread across the globe. Every country has access to at least some form of renewable energy, be it solar, wind, biomass, hydro, oceanic, or geothermal. This creates the possibility for more countries to produce a larger share of their energy needs domestically, to the extent domestic capacity allows, and to diversify their portfolio. This lowers consumers' import-dependence, to the point that they might become new producers, giving rise to the view that they are the 'winners' of a transition to renewables.[17] Nevertheless, some countries are better endowed to become efficient renewable energy producers than others, due to solar radiation, wind speeds, biomass stocks, etc. being more favorable in certain locations. This leaves less fortunate countries with a choice: should they produce renewable energy themselves (good for supply security) or should they buy it elsewhere (good for affordability)? In other words, while the distinction between net-producers and net-importers blurs it continues to exist in a different fashion. Nonetheless, more leverage is given to current consumers as they can more easily diversify away from gas and oil, and competition between consumers to get access to overseas fossil fuel reserves lessens. Producer dominance is further eroded by a decrease in demand (growth) for oil and gas as the transition progresses. Were peak oil and energy scarcity core terms a few years ago, nowadays oil depletion is overtaken by demand decline in some regions. This essentially creates a situation of oil abundance and low prices, which in turn make oil majors and producer countries worry about stranded assets and an impending carbon bubble. As revenues get less, political instability in exporting countries and regions can be expected. This is why net-exporters are generally perceived as the 'losers' of the energy transition. One needs to keep in mind here though that the capital reserves and geographical position make Gulf countries strong contenders to become future solar energy exporters. While markets are set to become less oligopolistic, market prices could be more inherently volatile[18] due to the intermittent nature of some renewable

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[17] It needs to be kept in mind that while renewables currently represent a source of diversification, towards the end of the energy transition (when fossil fuels are being phased out and renewables dominate the energy mix) this no longer holds true.

[18] Inherently, because solar and wind sources are intermittent by nature and oil and gas price instability is usually caused by specific economic and political developments.

sources, with predictability also varying.[19] This would replace price volatility induced by political instability in oil and gas regions. Moreover, the intermittency could make availability at the right time more pressing than import dependence, moving emphasis from strategic reserves to grid balancing and short-term storage. Countries with unique storage possibilities such as alpine lakes or other balancing technologies are strategically well-positioned, especially if they can deliver at times of peak demand or supply. In all, we may expect a shift from strategic leverage of producers to many countries having leverage: efficient producers, large consumers, and countries able to render cheap balancing services. This also results in a shift in concerns about getting access to overseas resources, diversification policies, and strategic reserves to a strategic make-or-buy decision between secure domestic production and cheap imports, availability at the right time and price volatility, and access to biomass and more geographically bound renewable sources.

A second set of expectations surrounds the increasingly decentralized nature of energy production by and for a new and more varied set of local actors, enabling new business models and local empowerment. Energy is currently produced and refined using large, i.e. high capacity, centralized facilities either close to the extraction point or demand centers. Generation requires a continuous input of raw materials but produces a stable output. Markets are dominated by big (multi)national companies. In contrast, renewable energy lends itself to the production of smaller quantities via local facilities or units run by private individuals, businesses, and cooperatives. This not only introduces new business models (less oriented towards maximizing profits, more towards minimizing costs), but also takes market shares away from established companies in energy markets. Power companies are hence likely to share residential markets with households, small businesses, and cooperatives. As the heavy industry needs large-scale centralized production due to their high energy demands, energy markets themselves are likely to become a more business to business affair. Moreover, issues of integrating new decentral renewable production technologies into existing grids and managing the intermittency of local power generation may require new modes of operating these systems. Local balancing and storage, grid reinforcements and reserve capacity, demand side management, and a good spatial distribution of renewables might be paramount in facilitating local generation. The role of smart grids (ICT) and flexibility will be instrumental in this. In addition, decentralized energy generation may reduce energy

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[19] Wind and solar energy production is characterized by relatively high capex and very low opex per kWh. Solar panels and wind turbines operate at near zero marginal costs. In times of plenty sun or wind the market is hence flooded with extremely cheap electricity. Because of this effect, Germany experiences negative electricity prices several times a year (Nicolosi 2010). Of course, the opposite also holds: in times of little sun or wind, electricity is likely to have a higher price than current coal power plants provide. Such fluctuations send strong price signals to consumers to balance their energy use over the day, given on the spot pricing, and to producers to invest in generating capacity of those renewables that can be harvested at peak-demand. They also signal the need for balancing capacity, not just for operational reliability, but also for market stability's sake. Options in this regard are large-scale storage facilities and interconnector capacity to link various sources to the same cross-border grid to manage intermittency effects.

poverty, spur local development, and empower local communities as it provides energy access, employment, and revenues to areas now lacking them. In short, cash flows do not leave the area and the independence empowers the community. This potentially lessens social unrest but could also fuel separatist tendencies to the dissatisfaction of national governments. Local production may also go off-grid. Apart from raising operational and regulatory issues, this ‘island mode’ provides countries with the means to protect domestic markets from foreign competition because without a physical connection these local networks essentially go off-market, though prices in energy markets may still guide prices in off-grid areas.[20] One additional effect of decentral renewable energy generation is the localization of environmental impacts. The impact of hydropower dams, the stench of biogas digesters, and nimby reactions towards onshore wind parks are much more local than CO_2 emissions. Growing competition and conflict over various uses of land are also to be expected as the smaller, but more plentiful renewable energy sites take up much more space per kWh than a few large fossil installations.[21] In any case, future electricity grids will need to combine decentralized production with existing centralized facilities, i.e. be ready to accommodate a more varied set of actors, technologies, and issues.

A third expectation is that of increasing competition for rare earth materials and clean tech know-how between countries that aspire to be industrial leaders in renewable generation technology. Currently, most materials used in oil and gas infrastructures are relatively abundant, but renewable energy generation technologies rely on a variety of rare earth materials. For example, solar PV panels, batteries, and wind turbines use indium, lithium, neodymium respectively (among others). Moreover, renewable energy is not a dense form of energy and requires more generation equipment, and hence more rare materials, to generate the same amount of kWh as fossil fuels. It may thus be expected that countries harboring these materials will find a comfortable position whereas some clean tech producers will develop new dependencies on countries possessing such materials. This development is made worse by the fact that modern economies are increasingly using a more diverse set of rare earth materials in a variety of sectors. Then again, this expectation may not materialize because alternative materials and technologies, recycling of materials, the single-import nature of these materials,[22] and the likely

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[20] A benefit from decentralization and ‘island mode’ is a decrease in vulnerability to deliberate (cyber) attacks that target the system as a whole. The risk is, however, that the consequences of a disruption in the local network might be more severe as there is no option for rerouting. Another drawback is that if power would become markedly cheaper abroad, the off-grid areas cannot purchase/import it.

[21] This relates not only to the fuel versus food debate for biofuels but also to local spatial planning regarding the use of scarce land in communities. Space availability may well prove to be the most limiting factor to the share decentral renewables can take in the energy mix.

[22] Once solar panels and wind turbines are constructed, they can produce power throughout their life-cycle. Coal and gas fired power plants, in contrast, require a continuous supply of resources throughout their life-cycle to produce electricity.

(re)opening of mines if these materials are used as political pressure[23] provide possibilities to remedy the situation. Countries exporting rare earth materials for their part must avoid the pitfalls of a new resource curse. Clean tech generation know-how, in contrast, is of high industrial value and certain to be of great interest. Renewable energy generation technologies are a fast-growing market in which industrial leadership could reap great benefits in terms of revenues and employment. We can already observe how the US, Germany, and China, for example, consider renewables an important export sector. Access to technical know-how, patents, and finance is crucial for the ability to exploit this economic opportunity to its fullest. It can be safely expected that industrial rivalry over clean tech equipment will intensify the coming decades as the energy transition picks up speed. It may only diminish once the market is saturated, i.e. until capacity is widely installed and demand is limited to replacement.[24]

A final set of expectations centers around the electrification of energy systems.[25] Fossil fuels are transported as raw materials in a solid, liquid, or gaseous state across the globe using a variety of means (pipelines, tankers, rail, road) and without much loss of energy content. The infrastructure consists of technically separable assets and allows for efficient storage in depots and strategic reserves. In turn, elaborate long-distance infrastructures over sea and land connect user centers with coal, oil, and natural gas producing countries via hubs and transfer facilities across the globe. Geopolitical risks stem from crucial infrastructure bottlenecks like pipelines and shipping lanes vulnerable to (deliberate) disruption. In contrast, electricity is the energy carrier for most renewable energy sources, and certainly those with the most potential (Ellabban et al. 2014). Moreover, the increasing use of electric vehicles is likely to add to the growing importance of the electricity grid in future energy distribution.[26] Electricity has distinct features compared to coal, oil,

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[23] Of course, it is questionable whether the mining sector can keep up once the energy transition picks up speed; the opening of new mines knows long lead times (many years, if not a decade) before they are fully operational. Then again, rare earth materials are not actually rare, they are mostly hard to extract from their surroundings and chemical bonds.

[24] It is important to stress that this expectation only reflects the market for generation equipment, not those for energy sources or energy carriers. There, things are set to change more drastically. Fossil fuels are traded in large volumes after production facilities are in place; gas-fired power plants or small-scale oil generators need a continuous supply to produce electricity. In contrast, wind and solar radiation are free goods. Moreover, renewable energy is likely to be traded less. As part of consumption is met by local generation, there is less demand on wholesale markets for energy from centralized installations.

[25] This trend does not imply all things will be electric. A renewable future, for example, will likely feature biogas pipelines and district heating for heat systems and hydrogen as energy carrier for heavy trucks, shipping, and aviation. It does, however, mark an overall trend away from the use of multiple modalities to a concentration around the use of electricity.

[26] The switch to renewables also affects mobility. While oil is dominant today, battery electric vehicles, hydrogen fuel cell technologies, and biofuels will make up renewable based transport. The market is likely to be split between BEV for personal transportation on the one hand and H2FC for heavy duty vehicles, shipping, and aviation on the other, with biofuels being a transition fuel until BEVs and H2FCVs are sufficiently established.

and gas that represent new challenges. As electricity transport faces long-distance losses, grids tend to span countries and continents, not the globe. This essentially entails a regionalization of energy relations. It also implies a limit to the size of ‘supergrids’ and less long-distance shipping of oil, coal, and gas, i.e. a more land based transportation of energy. Electrification also implies more operational effort as electricity requires a physically interconnected grid and the instantaneous balancing of demand and supply. Moreover, electricity is costly to store besides pumped hydro storage[27] and requires on the spot emergency response to prevent blackouts, as accidents may cascade from one section of the grid to another in a matter of seconds. Such a grid has strict managerial requirements; cross-border arrangements regarding ownership and decision rights with respect to infrastructure development, operation, and regulation are a necessity. Combined with the abundance of renewables, this shifts emphasis from a focus on continuity of commodity supply to continuity of service supply. The regional and interconnected nature of the grid, however, reduces the possibility to interrupt delivery to single countries. Any interruption is likely to affect other countries and there will be a common interest in maintaining grid operations.[28] Then again, the effect of a deliberate action is immediate and cannot be circumvented by strategic electricity reserves other than maintaining domestic generation and transport overcapacity (in the absence of large-scale storage possibilities). Lastly, while renewable sources may be a source of diversification away from oil and gas, in the long run an increasing electrification of the energy system is the opposite as it implies the reliance on a single transport modality.

If we consider these expectations as ongoing trends in a world that increasingly replaces fossil fuels by renewable energy sources, we may reflect on their logical conclusion (Scholten and Bosman 2013, 2016). The combination of trends would paint a picture of an end state, if you will, of a world centered around ‘grid communities’, made up of ‘prosumer countries’. In the grid community, countries share or even jointly operate (parts of) a tightly integrated electricity network and face a make-or-buy choice depending on their national capacity to service their energy needs, options for reliable cheap imports, reliability of energy partners, and political-economic-military capabilities to get what they want in case of emergency. The grid community would be of a continental size, a supergrid if you will, due to the losses of long-distance electricity transport. With the abundance of renewable sources and the option of more self-provision always on the table, getting access is not the primary concern for countries, but makes place for control over infrastructure (asset) development, operation, and regulation to exert influence over electricity flows. This way market access, low prices, and availability at the right

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[27] While storage methods exist (pumped hydro storage, flywheels, batteries, super capacitors, compressed air energy storage, power-to-gas), their efficiency leaves much to be desired and those means with the greatest capacity have geographic limitations.

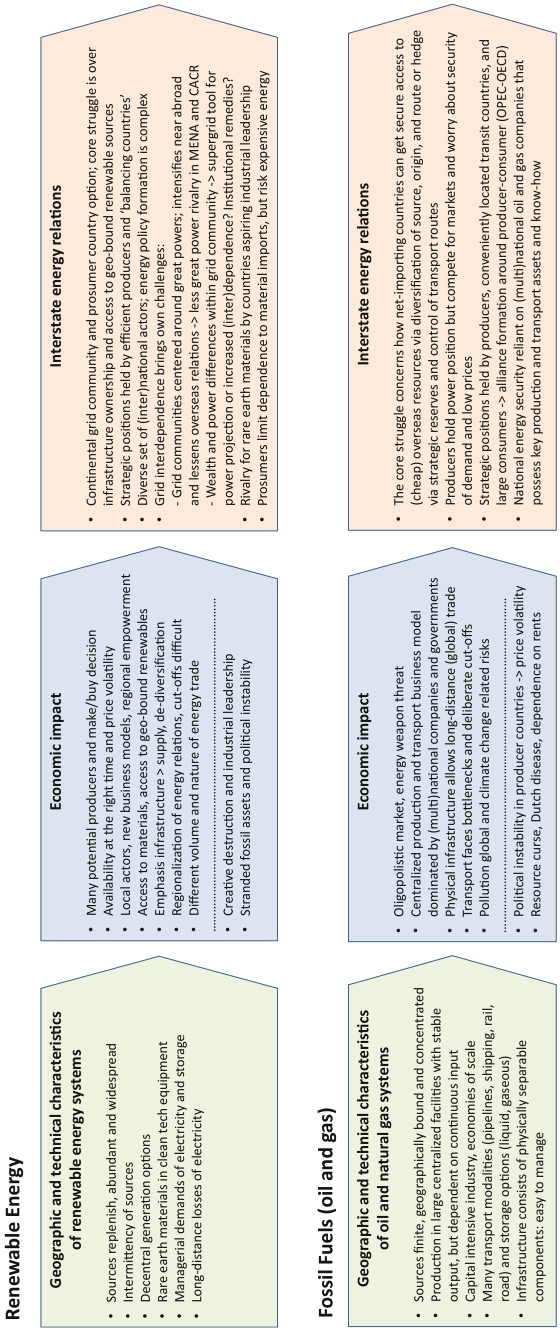
[28] This differs from oil and gas where the effect of an accident or sabotage action may be isolated to the part where it occurred and the entire network and its users need not be all, nor immediately, affected.

time can be assured. Cut-offs would be less of a concern. Targeting single countries within the grid community without affecting others would be difficult due to its joint and interconnected nature.

In this world of grid interdependence, geopolitical tensions are reduced but power politics is far from gone. Moreover, grid communities intensify near abroad and lessen overseas energy relations. First, the formation of grid communities is likely to occur around great powers rather than between them. Countries are likely to avoid membership in a grid community if rival powers hold a strong position (Japan and China or the EU and Russia for example). This leads to few connections between grid communities of great powers and limits their dependencies to countries part of their grid community. However, it is unclear how differences in economic development and political power play out within a grid community. For example, the position of the US in North-America is rather different from that of Germany in Europe as the former is hegemonic and the latter more a 'primus inter pares'. It is likely, however, that efficient producers, large consumers, and countries with cheap storage means hold strategic advantages. Nevertheless, it is uncertain whether a supergrid allows great powers to control their backyards or merely creates more dependencies. Moreover, energy politics is likely to become more complex when decentral generation and supergrids add new local and international actors and put pressure on national energy policies. Second, if demand can be met by production in the grid community, dependency on overseas resources and accompanying infrastructure corridors is greatly reduced. Only the need to import rare materials for clean energy generation technology remains. We may hence expect fewer entanglements of great powers in the MENA and CACR and frictions between them over access to resources, depoliticizing both regions in the process, but more activity in regions harboring rare earth materials and rivalry between actors aspiring industrial leadership in renewable energy production technology.

The alternative to grid connection would be to opt for domestic production, as far as domestic capacity allows, foregoing cheaper imports to avoid any foreign dependency. The lack of the need for cross-border energy trade implies that geopolitical tensions are reduced to those related to rare materials and/or clean generation technology imports. Of course, tensions between provinces within countries can remain as some will compete for renewable projects for purpose of revenue and employment benefits. In this light, if generation occurs in a very decentralized fashion, through small-scale turbines and solar panels by households, cooperatives, and companies for example, a large part of energy moves out of the political realm altogether. The most likely outcome, however, will be a mixed picture, in which countries will source a strategic share of their energy domestically and exploit the efficiency gains international trade offers.

Such an end-state leads to very different strategic realities for countries than those of fossil fuels. Geopolitical dependencies do not disappear, but are different. While renewables solve many contemporary energy security issues related to fossil fuels such as dependence on overseas deposits, air pollution and climate change, pipeline politics, and shipping bottlenecks, they create a range of new challenges (see Fig. 1.2 for an overview of the most notable differences). In all, it seems that



Renewable Energy

Geographic and technical characteristics of renewable energy systems

- Sources replenish, abundant and widespread
- Intermittency of sources
- Decentral generation options
- Rare earth materials in clean tech equipment
- Managerial demands of electricity and storage
- Long-distance losses of electricity

Economic impact

- Many potential producers and make/buy decision
- Availability at the right time and price volatility
- Local actors, new business models, regional empowerment
- Access to materials, access to geo-bound renewables
- Emphasis infrastructure > supply, de-diversification
- Regionalization of energy relations, cut-offs difficult
- Different volume and nature of energy trade

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- Creative destruction and industrial leadership
- Stranded fossil assets and political instability

Interstate energy relations

- Continental grid community and prosumer country option; core struggle is over infrastructure ownership and access to geo-bound renewable sources
- Strategic positions held by efficient producers and 'balancing countries'
- Diverse set of (inter)national actors; energy policy formation is complex
- Grid interdependence brings own challenges:
  - Grid communities centered around great powers; intensifies near abroad and lessens overseas relations -> less great power rivalry in MENA and CACR
  - Wealth and power differences within grid community -> supergrid tool for power projection or increased (inter)dependence? Institutional remedies?
- Rivalry for rare earth materials by countries aspiring industrial leadership
- Prosumers limit dependence to material imports, but risk expensive energy

Fossil Fuels (oil and gas)

Geographic and technical characteristics of oil and natural gas systems

- Sources finite, geographically bound and concentrated
- Production in large centralized facilities with stable output, but dependent on continuous input
- Capital intensive industry, economies of scale
- Many transport modalities (pipelines, shipping, rail, road) and storage options (liquid, gaseous)
- Infrastructure consists of physically separable components: easy to manage

Economic impact

- Oligopolistic market, energy weapon threat
- Centralized production and transport business model dominated by (multi)national companies and governments
- Physical infrastructure allows long-distance (global) trade
- Transport faces bottlenecks and deliberate cut-offs
- Pollution global and climate change related risks

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- Political instability in producer countries -> price volatility
- Resource curse, Dutch disease, dependence on rents

Interstate energy relations

- The core struggle concerns how net-importing countries can get secure access to (cheap) overseas resources via diversification of source, origin, and route or hedge via strategic reserves and control of transport routes
- Producers hold power position but compete for markets and worry about security of demand and low prices
- Strategic positions held by producers, conveniently located transit countries, and large consumers -> alliance formation around producer-consumer (OPEC-OECD)
- National energy security reliant on (multi)national oil and gas companies that possess key production and transport assets and know-how

Fig. 1.2 The geopolitics of renewables and fossil fuels. *Note* The implications of the transition to renewables under the dotted lines represent those aspects that cannot be attributed to the geographic and technical characteristics of renewable energy systems but are an effect of the transition towards renewable energy (see Sect. 1.2) renewables will alleviate interstate energy struggles overall but make them more complex and local-regional. We must not forget this. The risk of investigating the geopolitical implications of renewable energy systems is an overemphasis on the new challenges that renewables bring, not the ones that they solve. In the end, renewables add to existing considerations of countries while taking away others, redefining which dimensions are prevalent, and slowly but surely reshape the energy game.

The strategic realities of the end-state can be considered the general principles or determinants that shape the nature of interstate renewable energy relations. They are, however, based on the assumption that all countries are served by 100% renewable energy, a future far removed from the contemporary situation where fossil fuels dominate the global energy mix with a share of 86% (BP 2015). As this situation will only slowly change over the coming decades, the question becomes what we can already observe of our expectations and, more fundamentally, in how far we can actually expect to see them in a hybrid system stuck in a transition from fossil fuels towards renewables. In other words, what geopolitical struggles can we expect to see at 30, 50, and 70% renewables in the global energy mix or in 2040, 2060, and 2080, i.e. at various stages of the energy transition?

In addition, the strategic realities are solely based on the geographic and technical characteristics of renewable energy systems without embedding them in the broader real-life context where other technological, operational, economic, environmental, social, and political developments play an equally if not more decisive role in framing energy systems and interstate energy relations. Our expectations are hence geographically and technologically deterministic in nature. One obvious example is the lack of great power dynamics in this equation. How would our expectations differ in scenarios that represent different global political constellations (unipolarity vs. multipolarity; multilateral institutions vs. fragmentation) and degrees of trust in markets (free-trade vs. protectionism; globalization vs. regional blocks) such as the Regions & Empires and Markets & Institutions scenario's developed by the Clingendael International Energy Programme (CIEP 2002; Correlje and van der Linde 2006) or Shell's Mountains and Oceans scenario's (2013). Will policy considerations of countries differ in terms of a preference for security of supply or cost-efficiency? In addition, technical and operational breakthroughs in batteries or smart grids or a noticeable worsening of climate change and pollution also determine the shape of energy systems and the speed of the energy transition. We may also find that some of the global potential of renewable energy cannot actually be exploited; the material requirements and space available for renewable power generation are limited (and perhaps even altogether insufficient to power the globe given rising consumption levels). And what about the influence of powerful political and business interests, financial markets, consumer preferences, or more subtle forms of technological and institutional lock-in and path-dependence in determining the shape of energy systems? We would hence do well to remember that countries' energy foreign policy is not only driven by considerations stemming from renewables' characteristics; a myriad of other developments co-determine the nature of interstate energy relations.

Summing up, while we might have some informed expectations and ideas about an abstract, distant future, we lack a coherent picture of how renewables are actually changing the current energy game and what the implications of this will be for the coming decades. In other words, what impacts of renewables can we already observe and how will they manifest themselves in a setting where fossil fuels and renewables both share a significant place in the global energy mix and where a myriad of contextual factors co-determine interstate energy relations? This brings us back to the main question of this volume.

1.5 Structure of the Volume

This volume explores what the transition towards renewable energy implies for interstate energy relations. By introducing the field of geopolitics of renewables, developing an analytical framework, and posing expectations, this chapter has laid the groundwork for a comprehensive overview of contemporary developments. We do not strive to be exhaustive in this endeavor, but rather aim to showcase the key ways in which renewables are reshaping interstate energy relations. The overview is structured along three parts, representing the three levels of analysis. The first part presents the key developments that frame the emerging global energy game among great powers from a geopolitics perspective (Chap. 2), considering the energy transition as a force of creative destruction in global energy markets, and then delves deeper into the questions which countries are the likely 'winners' (Chap. 3) and how the energy transition affects current net-exporters (Chap. 4). In the process, the general picture of current net-importers and net-exporters as winners and losers respectively is nuanced. The second part zooms in on how the US, Germany, China, and India approach, experience, and handle the energy transition. This country specific perspective highlights what these established and rising powers perceive to be their main issues, the opportunities and challenges for their regional and bilateral energy relations, and the strategies that they may employ to reap the benefits and mitigate the drawbacks of the energy transition. The US, Germany, China and India are treated in Chaps. 5, 6, 7, and 8 respectively. The third part discusses how national energy systems, markets, and policy are pressured from below and above by decentral generation and microgrids on the one hand and plans for centralized facilities and supergrids on the other (Chaps. 9 and 10). The part ends with an investigation of institutional responses to the international challenges stemming from these developments (Chap. 11). The conclusion summarizes the core developments shaping the geopolitics of renewables, using the framework to reflect on the relationship under study and our expectations. It also draws overarching lessons for the field of geopolitics of renewables and regarding the challenges and opportunities countries face in securing an affordable energy supply in the emerging energy game.

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Part I

The Emerging Global Energy Game; Winners and Losers

Chapter 2
Geopolitics of the Renewable Energy Game and Its Potential Impact upon Global Power Relations

David Criekemans

2.1 Introduction

Geopolitics is the scientific field of study belonging to both Political Geography and International Relations, which investigates the interaction between politically acting (wo)men and their surrounding territoriality (in its three dimensions; physical-geographical, human-geographical and spatial) (Criekemans 2007, 2009). The field of Geopolitics has always been very interested in energy questions since *conventional energy sources* such as oil, natural gas and coal constitute physical-geographical variables of strategic importance. Within Geopolitics, it is recognized that the energy regime of the global system and the energy relations between producer countries, transit countries and consumer countries are important variables which can influence international relations. The factor 'location'—where the energy resources are, and via which routes can they be brought to (potentially rival) consumer countries—constitutes an important area of study within the field of Geopolitics. The 'Geopolitics of (Conventional) Energy' entails a whole literature in itself. Exploring and developing conventional energy (oil, natural gas, coal) demands for huge capital investments and a military machine to control. Today, in an age of increasing scarcity, producer, transit and consumer countries are positioning themselves geopolitically so as to safeguard their energy security. Of course, energy and location in themselves do not explain everything in international relations, otherwise one would lapse into geographic or energetic determinism. But

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the way in which societies shape their *energy mix*, is central to both their chances for development and survival. Countries and areas which have energy (technology) at their disposal potentially have better cards compared to other countries. Nevertheless all countries, regions and areas are interconnected when it comes to the complexity of energetic relations, which in itself is translated into international-political relations and power dynamics. We know what the Geopolitics of Conventional Energy entails. But as countries in the world will in the coming decades move towards more renewable energy in their respective energy mixes, *how will this affect global power relations? What trends and developments can we see today? To what extend is the Geopolitics of Renewable Energy different or similar compared to the Geopolitics of Conventional Energy?* In this contribution we will focus on the great powers, although also some smaller states have become ‘great’ in the renewable energy world, such as Denmark or Switzerland. Remarkably enough the current literature in Geopolitics and International Relations has only barely scratched the surface with regard to exploring the potential geopolitical effects of the transition towards more renewable energy sources. This book can be seen as a first comprehensive effort to bring some thoughts on this matter together.

Renewable energy has come into the picture in the past years as a result of a number of combining factors and trends. First, the last decades have clearly shown that the burning of non-renewable, fossil fuels leads to CO_2-emissions, the exhausting of resources, local environmental degradation and climate change. Second, the entering into the world economic scene of a couple of billion people in especially Asia structurally impacts the demand for energy, as a result of which (conventional) energy scarcity could become a real possibility in the coming decades. On the other hand, unconventional sources such as shale oil and gas, tar sand and deep sea oil all try to make up for this expected shortage, but they all are—without exception—more ‘dramatic’ in terms of their environmental consequences. All these elements push decision makers to make new choices in the direction of more renewable forms of energy. Also the markets influence this process, although this evolved jerkily in the past couple of years. When the stock markets think a situation of scarcity might develop, like was the case in the summer of 2008 (when a barrel of oil reached the staggering record price of $147), then the prices of fossil energy can multiply in a short time frame and create volatility in the market. As a result of this, renewable energy becomes more interesting and economic in comparison to traditional forms of energy. When a few months later in 2008 the energy prices collapsed as a result of the economic crisis, a reverse process seemed to develop in the market—resulting finally in decreasing investments for several years in renewable energy. Such dynamics make the study of renewable energy not very easy within a broader geo-economical and geopolitical context. Many variables are at play. However, the efficiency of renewable energy has since 2008 dramatically increased. Could fossil energy stocks become *stranded assets*[1] in the future? Much of the wealth of some of the major powers in the world was and still is founded on fossil energy resources. In July 2017, first France and then Great Britain issued a ban on petrol and diesel vehicles by 2040. Natural gas will quite probably become a "transition fuel" towards a renewable energy future. It will be able to top off the low peaks in the renewable energy production as long as the major technological issue of renewable energy storage is not yet solved. However, Paltsev has remarked correctly that if the world is serious about the Paris Agreement targets, then even natural gas producers will have to eliminate their own greenhouse gas emissions (Paltsev 2016, 3). However, natural gas is much cleaner than oil or coal. Within current technologies, it seems to fit neatly with renewable energy as a source of back-up power for intermittent renewables. So the geopolitics of renewable energy will be for the coming fifteen years at least also a geopolitics of natural gas. The era of conventional oil is nevertheless wining down. In the Middle East, we therefore see a major geopolitical struggle between Saudi Arabia (the world's biggest conventional oil producer) and Iran (with major natural gas deposits). The transition towards more renewable energy and the intermediate period in between might drastically impact the power relations between countries, and also within countries. Is Saudi Arabia perhaps trying to slow down such countries as Iran and Qatar? Perhaps the Saudi elite knows all too well that the basis of its power is hollowing out rapidly as a result of the global climate response and anticipated dwindling of conventional oil. The stakes could never have been higher. Who will be the winners, who will be the losers? And how will renewable energy reshape the global and macro-regional geopolitical landscape?

This chapter tries to bring together some ideas on the geopolitics of renewable energy and its potential impact upon global power relations. It is structured as follows:

- *First*, we will lay out some internal and external geopolitical consequences of the energy transition;
- *Second*, we explain that the transition towards renewable energy in fact entails an "energy technology-revolution" or ET-revolution;
- *Third*, we will study the geopolitics of renewable energy in more detail—we will look at the global control over patents and knowledge. We will next investigate the potential of renewable energy sources and their geopolitical consequences. Special attention will also be given to the very topical case of lithium and the electric car;

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[1] Stranded assets are "assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities." Stranded assets can be caused by a variety of factors and are a phenomenon inherent in the 'creative destruction' of economic growth, transformation and innovation, as such they pose risks to individuals and firms and may have systemic implications. Coal and other hydrocarbon resources may have the potential to become stranded assets as the world engages in a fossil fuel phase out.

- *Last but not least*, we will try to formulate some conclusions on the specificity of the geopolitics of renewable energy and its potential impact upon global power relations.

2.2 Geopolitical Consequences of the Energy Transition

The coming energy transition towards renewable energy will produce far-reaching consequences, both from an internal-geopolitical and an external-geopolitical point of view.

From an internal-geopolitical perspective, the technological conversion which we will witness in the coming 25 years will be comparable to the industrial revolution at the end of the nineteenth to the beginning of the twentieth century. An energy transition constitutes one of the most sweeping turnarounds from both an economical and societal point of view, whether it constituted the shift from steam to coal, from coal to oil (and later natural gas), or today towards renewable forms of energy. It questions the economic fabric, it has implications for the societal structure, but also it touches upon the very core of politics. It is not a coincidence that most national states in Europe (and later also in the rest of the world) were established during an energy transition period from steam to coal and later to oil, which demanded huge piles of capital and a central political decision making. The national state and central power supply and distribution go hand in hand. They need one another. Those areas in the world with an exceptional large energy hunger, such as the United States of America or the People's Republic of China, will moreover feel the need to invest additionally in their respective military apparatus. They do this so as to secure their access to oil and natural gas. The fact that this sometimes puts democracy under pressure, is "a price which has to be paid". The imminent energy transition towards more renewable forms will be accompanied by a huge decentralisation of the energy supply. This will also impact upon the *res publica*, the organisation of political life. Local and regional governments will, if they invest heavily in renewable energy (and thus cleaner) technologies, dispose of more levers vis-à-vis their central counterparts than is the case today. This could potentially also be beneficial for the democratic standard of societies. At the same time, one can detect here also actors wishing to discourage this. The former central energy suppliers do not want to lose their monopoly position, and are willing to use various strategies and instruments so as to frustrate the growth of small renewable energy companies, or they just buy them. Here lies a role for all governments at all policy-levels to create an economic landscape which is more diverse, and which guarantees that no one is able to gain an upper hand (Criekemans 2010a, b, 2011).

From a geopolitical point of view, regions within major states might also gradually become stronger vis-à-vis their respective central governments. This would certainly be the case if the central government keeps lingering on in the fossil energy era, whereas a region pursues an active policy of investment in renewable energy combined with regulatory restrictions for fossil energy emissions. This is no longer something theoretical. Donald J. Trump as new president of the United States of America since January 2017 has championed the old oil and coal industry. On the other hand, states such as California are pursuing another high tech policy on climate change and energy transition. It is not a coincidence that a company such as the electric car manufacturer Tesla is based in California. On 1 June 2017, president Trump gave a major speech in the Rose Garden of the White House in which he stated that the United States would not implement the provisions embedded in the Paris agreement on climate change. The US, traditionally one of the major investors in renewable energy technology, would thus rather protect the old fossil industries. A state such as California would suffer greatly from such policies. Its whole business model is based upon marketing the technologies which they have pioneered in solar, wind and electric cars. In reaction to the decision of Trump, the governor of California Jerry Brown, immediately stated he would leave for China to make his own climate deal. California is the sixth economy in the world. Thanks to its continued investments since the oil crises of the 1970s, and the initiatives of Governor Arnold Schwarzenegger in the 2000s, a whole eco-system of renewable energy companies has emerged. The federal US policies under Trump have become detrimental to California, which now provokes a parallel diplomacy (also known as 'paradiplomacy') by the state governor vis-à-vis external actors. There is something about the renewable energy world that is potentially different compared to the old fossil world; it is all about the political will to invest in renewable technologies. That could thus even change the geopolitical power relations between the central government and its the regions in future geopolitics (Criekemans 2017). The jury is still out on how fundamental this change in relations will be.

From an external-geopolitical perspective, those countries who today invest in renewable energy sources and technology may become the dominant geopolitical players tomorrow. It is clear that the uni-multipolar order led by the US which came about after 1991, has waned. Some predict a duo-multipolar order (led by the US and China), others think that the external-geopolitical landscape of a world run on renewable energy will be more in terms of a *multipolar world* where power is more spread equally across the globe. Recently the landscape has however changed with Donald J. Trump in office. Direct and indirect subsidies for renewable energy are being cut back under this new Administration. On the other hand, China is emboldened. Its own National Energy Administration is predicting a further rapid growth in the clean energy sector; 2.5 trillion yuan ($361 billion) into renewable power generation by 2020. Some 700 billion yuan will go towards wind farms, 500 billion to hydro power with tidal and geothermal getting the rest (Mason 2017). Is Trump an opportunity for China to get ahead of the curve? At the same time, the Indian government of Prime Minister Moodi is investing heavily in renewable energy. There is strong growth over many years to be expected here, both in the public and private sector. However, with regard to the financing of renewable energy projects, India will need to invest close to $150 billion to meet its 2022 renewable energy targets (S.a. 2017). The potential of the Asian markets alone is huge. Will these markets outpace the Western markets? With the federal US now in crisis and the pace of European investment growth in renewables being currently slower, that may prove to be a risk for the "status quo" powers of the West as consumer countries. If the global energy regime changes the underpinnings of Western power might also be affected. But to really understand the geopolitics of renewable energy and its consequences in terms of power distribution, one needs to appreciate the technological dimension better.

2.3 The Transition Towards Renewable Energy Entails an 'ET-Revolution'

The transition towards more renewable energy in countries and regions entails more than a mere change in the energy mix (See also: IEA 2004, 2005, 2007a, b, 2008a, b, 2009). The transition entails the conversion of an energy industry which was merely based upon the extraction of fossil energy sources to a mainly technology driven sector. The energy industry will thus gradually become a technological sector, and will be combined with the decentralised developments from the IT-sector of the nineties. That is why the evolution towards renewable energy is sometimes called an "*ET-Revolution*", or "*Energy Technology-Revolution*" (See also: Weiss and Bonvillian 2009). This technological revolution is certainly developing in the sectors of solar energy and wind energy. Critics could state that it is less visible in the area of biomass/bioenergy, because this source of energy potentially needs less technological innovations. To a certain extent this could be true. However, this traditionalist view does not take into account the awakening sector of *biobased chemistry*, which will gradually replace the petrochemical industry. As the conventional oil production will peak somewhere between the short and medium term, it will become technologically necessary to find replacements for all consumer products which are used and based upon oil. One would be amazed how dependent current societies still are upon oil, and how necessary it is to find replacement products in each and every of these domains. Moreover, one of the main reasons why the agricultural sector in the developed world is performing so well, is because fertilizers are used. Most of these are today still derivatives of oil products.

Those who study the geopolitics of renewable energy must thus take into account that technology plays a very important component in this. Here the geopolitical concept coined by Daniel Deudney, '*geotechnical ensemble*', could be applied (Deudney 1989, 1997, 2000). The new technologies that are developed together with the geographical opportunities and limitations of certain geographical areas, will determine the new geopolitical context within which countries, regions and territories will be able to operate, create welfare and wellness, and develop a *power base*—literally but also figuratively. Those territories, who invest today in developing the technologies and the standards that accompany them, will therefore have a much better starting position from which to create that power base. On the other hand, most technologies in renewable energy and the clean tech sector are so complex that international cooperation is needed to bring them about.

In 2010, Levi, Economy, O'Neill and Segal convincingly wrote in *Foreign Affairs* that "*an energy agenda built on fears of a clean-energy race could quickly backfire. Technology advances most rapidly when researchers, firms and governments build on one another's successes. When a clean-energy investment is seen as a zero sum game aimed primarily at boosting national competitiveness, however, states often erect barriers. They pursue trade and industrial policies that deter foreigners from participating in the clean-energy sectors of their economies, rather than adopting approaches that accelerate cross-border cooperation. This slows down the very innovation that they are trying to promote at home and simultaneously stifles innovation abroad.*" (Levi et al. 2010, 111).

Patrick Criqui, director of research at CNRS @ the University of Grenoble wrote in 2016 that the climate agreement of Paris constitutes a major break in the geopolitics of energy, at three levels (Criqui 2016). First, it will dramatically change the dynamics between forms of energy and technology in all regions of the world; carbon intensive technologies will gradually be disqualified. Second, 'Paris' strengthens a multilateral solution to the battle against climate change instead of a national one. Third, 'Paris' is adaptive—which means that the diversified technological routes which countries will choose are left up to themselves.[2] They will most likely choose different routes or make other technological choices. From that diversity, there is a chance that some of these countries quite unexpectedly will make 'better choices'. Predicting future power relations then becomes a quite difficult undertaking. In total, Criqui believes this brings a new dimension to the technological quest for searching new renewable energy technologies. Criqui really believes a "fourth industrial revolution" is imminent, combining information technologies with the transformation of the material world. A combination of geopolitical and technological factors, the geo-technical ensemble, will play a role in determining who will be more and less successful. Let us explore its dimensions more in depth.

2.3.1 The Possibility of a Positive 'Societal Revolution' if the New Technologies Are 'Managed' in the Right Way

With renewable energy, geopolitics is potentially also at play *within* societies. The decentralisation of both the energy production and consumption of *renewables* entails the possibility of a societal revolution, in which local and regional groups of

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[2] Trump has put this back into question. However, the US can only officially exit 'Paris' on 4 November 2020 at the earliest, one day after the next American elections.

people can organise themselves more independently. If renewables are also managed in a decentralised way, one would no longer be dependent of central energy companies as was the case in the conventional energy regime. At least, this could be true with regard to the production of energy. Regarding the distribution, the story is more complex. Important will be who will manage the new electricity and energy grids of the future. Technology also here offers some new opportunities. The very latest technological evolutions with regard to '*smart grids*' could eventually make it possible for consumers to send their excess in produced solar energy *peer to peer* to other consumers across the grid. Currently, there are already some experiments in this regard in the Netherlands. Then it would become necessary to install 'smart meters' which have the capacity to detect instantly who has excess capacity and who does not. In this way, renewable energy potentially deals in a much more efficient way with energy shortages both within and between countries. Different sources of renewable energy can complement one another in an efficient way via smart grids. When the sun does not shine, the wind may blow harder, or there might be more tidal waves on the sea. Potentially all these technological developments could give "*power to the people*", as the American economist Jeremy Rifkin states. Rifkin calls this process a "re-globalisation from the bottom up" (Rifkin 2002).[3] Whereas the international energy regime of the oil age was top down, the energy regime of renewables will be bottom up, but only if individuals and societies take the chances to organise themselves and their energy needs. However, the central energy suppliers and network managers are not so pleased with these developments because it threatens the power structures upon which they base their activities. They offer to install renewable capacities in houses at reduced prices, as long as they get a service-monopoly. According to Rifkin, such an evolution could threaten the chances which renewable energy offers in the reinforcement of a country's own societal structures and nullify the advantages of a societal feeling of belonging together as a result of an interwoven web of *renewables* and smart grids. It is exactly in this *potential* for societal rejuvenation that the geopolitics of renewable energy is different from the geopolitics of conventional energy. However, the jury is still out of how this will further evolve. In the last couple of years, central energy companies are installing smart meters for free and build new business models around the data that is then being collected from their consumers. Will only those who manage to go completely off grid be really free? In that sense the chances for a societal revolution have perhaps grown smaller instead of bigger during the last

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[3] Again according to Rifkin, globalisation from the top down, has failed. It was based upon a too narrow energy regime; it involved only a fraction of the world's population and needed an enormous concentration of capital and military power to keep together. Rifkin states that the financial-economic crisis of 2008 was not so much created by the housing bubble in the US, but rather by the high energy prices in the summer of 2008. Less than two months later, the economic crisis took hold. Rifkin sees a direct relation or "perfect storm" between the economic crisis, the (conventional) energy crisis and the climate crisis. In this, he sees evidence that the oil age has reached its dawn, and thus that a new energy regime—this time based upon *renewables*—will gradually take its place.

years. In the geopolitics of renewable energy, states still seem to be the main actors. Their investment choices will highly affect the power game amongst them.

2.3.2 The Choices Which Have to Be Made by Governments: Which Renewable Energy Technologies Should One Invest in?

The current "Energy Technology-Revolution" makes it difficult for governments to make choices. The technological applications are often developing so fast that it is difficult to predict beforehand which technology will be economically more viable than the other. In the framework of the research for this chapter, we had conversations will many people from different sectors and backgrounds. Most of them state that governments should not lay their eggs in one basket, but should rather support a multitude of initiatives in renewable energy. The task of the government should be to create a good investment and enterprise climate so that the society itself and the research centres within it can produce new varieties of renewable energy. The government should also invest in innovation policy, but in a way so as to trigger innovation within the society and ground the innovations via patents and licence agreements. In this vision, the government should also stimulate different types of renewable energy-applications, and not focus only on *transport* or on *energy usage at home*, but also on *consumer products.* These three pillars should be taken into account when a government tries to deal with the energy-technology revolution.

2.3.3 The Choices Which Should Be Made by the Government Regarding the Scale of the New Technologies in Which One Should Invest

Another aspect and consequence of the ET-revolution is that one must take into account the scales of renewable energy projects. From a geo-economical and geopolitical point of view, one could make a plea for governments to focus on those projects which in an international context offer much visibility. Two cases are very revealing in this regard.

A first example is the failed *Desertec*-project, a proposed renewable energy grid in North Africa and the Middle East. However, in the wake of severe geopolitical destabilization in Northern Africa after the Arab Spring, the Desertec Industrial Initiative (DII) abandoned in 2013 its strategy to export solar power generated from the Sahara to Europe. It was also deemed "too expensive and too utopian". A combination of geopolitical and technological factors finally killed it, for now.

A second example is the *North Sea Offshore Grid Initiative*, a complex of thousands of windmills in the North Sea (see Fig. 2.1). The North Sea Offshore Grid was proposed by the European Commission in November 2008, in the Second Strategic Energy Review. This initiative identified this project as one of the six priority energy-infrastructural actions of the European Union. According to the Commission, the North Sea Offshore Grid could develop into one of the corner stones of a future European super grid. The political statement of the North Seas Countries Offshore Grid Initiative was signed on 7 December 2009 in the Energy Council of the European Union. This statement was signed by Germany, the United Kingdom, France, Denmark, Sweden, the Netherlands, Belgium, Ireland and Luxemburg. On 9 February 2010, the directors-general of Energy of the ten countries endorsed the proposals for a Memorandum of Understanding. On Friday 3 December 2010, in the run-up to the formal Council of Energy and during the Belgian EU Presidency, the ten states signed a cooperation agreement in order to jointly develop the offshore wind parks of the Northern Seas (the North Sea, the Channel, the Celtic Sea, the Irish Sea), a surface of 760.000 km^2 in total. This agreement constitutes an important step in the further development of renewable energy, since the theoretical energy capacity of European offshore wind energy is almost as big as the petroleum which is found in the Middle East. In this project, electricity would be transmitted via high-voltage direct current cables, allowing it to be sold and exchanged in all involved countries. It would also make it easier to optimise energy production (S.a. 2009). Norway's hydroelectric power plants could act as a "giant battery", storing the power produced and releasing it at peak times, or when wind strength is low. Several high-voltage direct current interconnectors such as a proposed cable between Norway and the United Kingdom have been seen as integral parts of the project. In a study for the European Commission, De Decker and Woyte identified four offshore grid scenarios for the North and Baltic Sea (De Decker and Woyte 2010). The exact positioning of the grid, and the required size, are in 2017 still under study.

From a geopolitical and geo-economical point of view, the *North Sea Offshore Grid* will be very important for the countries bordering the North Sea. But in June 2016, the people of Great Britain voted in favour of 'Brexit', and exit out of the European Union by March 2019. From a geopolitical perspective, this could endanger the North Sea Offshore Grid Initiative. This is why the minister-president of Flanders, Geert Bourgeois, proposed on 29 June 2017 in Göttingen an '*Integrated Strategy for the North Sea*' as a macro-strategy of the European Union to its neighbourhood region of the countries bordering the North Sea. Co-organising offshore wind energy, tidal wave energy and energy storage would constitute one of the main dimensions in such a new geopolitical cooperation project (Bourgeois 2017). It would also help to soften the blow from the UK's 'Brexit' out of the European Union. Renewable energy technologies are thus seen by the Flemish government (which is exclusively competent in areas as renewables and energy efficiency, internally but also in foreign affairs) as an important diplomatic tool and geopolitical strategy to bridge the current divides between 'Brussels' and 'London'. There is thus interesting evidence that new geopolitical challenges within Europe

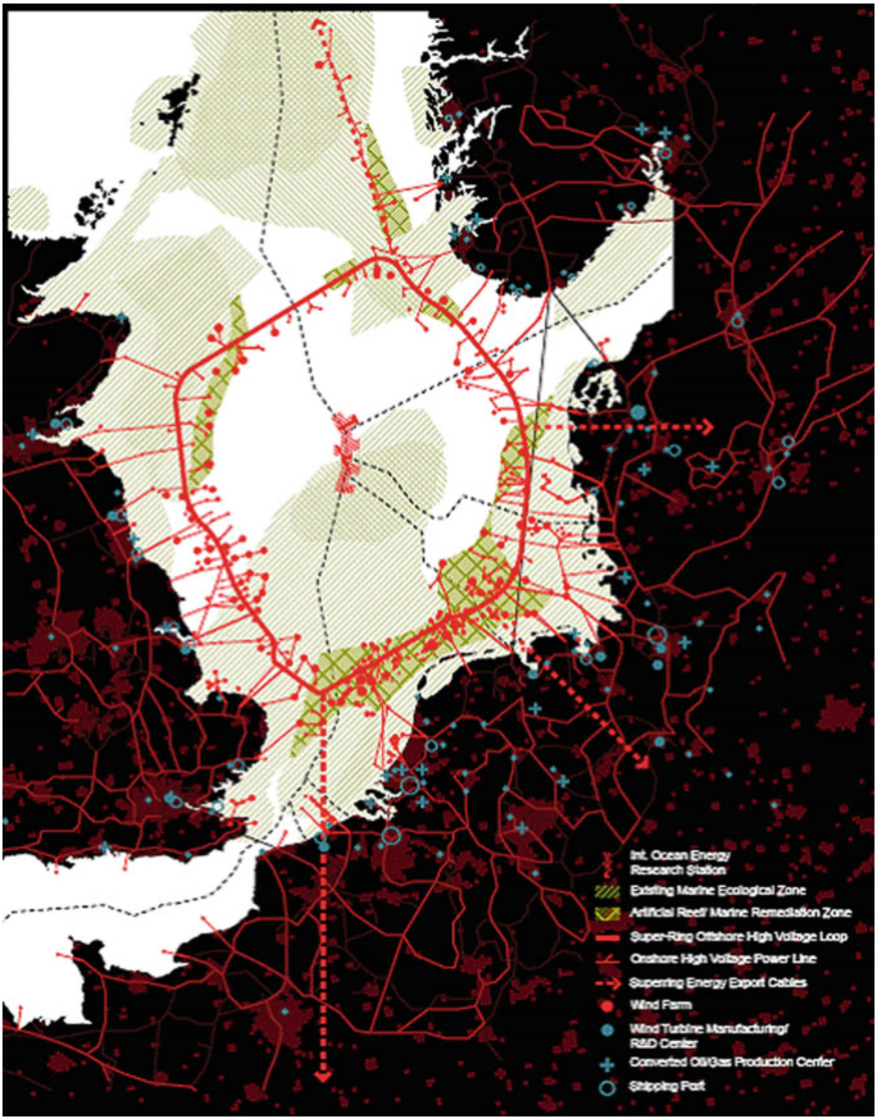

Fig. 2.1 The North Sea offshore grid initiative. *Source* European Commission

could also be softened via joint projects of renewable energy technology, inter-linkage and storage. The geo-technical ensemble also shows itself in interaction in these very dynamic cases.

Projects such as *Desertec* and the *North Sea Offshore Grid Initiative* are very *big projects*, which require a lot of international cooperation and coordination. However, from a geo-economic and geopolitical point of view, renewable energy projects are much more adaptable to different scales compared to conventional energy operations. Governments may want to invest in projects closer to home and *applications at a lower scale*, in houses (solar energy) or on the sea (wind energy and wave converter technology). A mass application of smaller projects in the existing energy systems would make renewable energy more stable and decentralised compared to conventional energy. The big projects in renewable energy suffer from similar security issues as compared to traditional energy projects; renewable electricity power lines could be as vulnerable as conventional energy pipelines. Important will be again where the power lines will run, and who will control them. The longer the distance of these power lines, the more they will also lose energy.

Perhaps it would be more wiser for governments to invest in small scale projects, that can be scaled up later? It is perhaps in this multiplying effect that an investment in renewable energy technologies can transform itself into a factor of geopolitical importance and 'power'. However, there is also a last element to consider in this equation.

2.3.4 New Technologies Vis-à-Vis 'Vested Interests'

A 'societal revolution' which brings energy closer to the people, in the end also offers chances to strengthen one's own democracy. It may even lead to lesser dependence vis-à-vis foreign energy companies, and the geopolitical objectives of some energy producer countries. However, much depends on how renewable energy is developed. Is it broadly developed within different parts of society, or is it rather developed by big existing energy groups? Within Europe, we see different situations in different countries. For instance, in France mostly the big energy chains are the ones that are developing renewable energy in a rather centralistic way. This has not always been very successful. Currently France is lagging behind Germany in this regard. In the Nordic countries, renewable energy is much more distributed. The Netherlands offers a more mixed situation—in first instance renewable energy seems much more distributed, on the other hand the vested interests of the bigger energy corporations such as the Gasunie are at play; biogas is only subsidized if it is pumped into the existing pipelines of the Gasunie and similar vested companies. This could potentially break the societal advantages that *could* be linked with the energy-technology revolution. Some interviewees state that one should not be naïve; only if renewable energy is applied everywhere in society, can the transition towards renewable energy take place. Only then will we also really see the multiplying effect in terms of shifting geopolitical power. In the Western model, a combination of private and public capital is needed, whereas in for instance China the state capitalist system seems to be the central financing and decision-making system in terms of the technologies that are being invested in. One could hypothesize that state capitalism will probably be more prudent with regard to the 'vested interests' in society. In private capitalist systems however, the process of ‘creative destruction’ can wield more freely—provided the rules of the game are not rigged in favour of the vested interests. Unfortunately, they often are via old subsidy and regulatory regimes designed for conventional fossil energy firms.

One needs a lot of capital to create this transfer and thus big energy companies will remain players, and there will remain a collusion between the economic and political elites on the bigger geo-economic and geopolitical stakes in the energy business. The only difference will be that the form of energy upon which this process will be based, will be another one, or a combination of many different forms of renewable energy.

2.4 The Geopolitics of Renewable Energy in More Detail

2.4.1 The Global Control Over Patents and Knowledge

According to Guillaume Sainteny, there are also some other geopolitical dimensions in the global developments related to renewable energy. One can speak of *a global struggle for the control over companies and the added value that they will produce*. In order to determine the position of countries and regions, one could utilize three criteria; (1) how many patents are awarded; (2) the relative weight of the capital investments in renewable energy, and (3) the presence of leading companies in this new industry. What is interesting, is that an application of these parameters leads to similar countries popping up on the radar screen of the researcher (Sainteny 2010).

For the period 2001–2005, the figures with regard to the awarded patents, are as follows:

- In the *wind energy-industry*, Germany owned 24% of all patents in the world, Japan 23%, the US 10%, followed by China 5%, Russia 5%, South Korea 5%, Denmark 4.5%, the United Kingdom 3%, Spain 3%, and France 2%;
- In the *solar energy-industry* Japan owned 50% of all patents, South Korea 11.5%, the US 11%, China 7%, Germany 6.5%, followed by Russia 1.5%, the Netherlands 1.5%, Australia 1%, the United Kingdom 1%, and France 0.8%;
- With regard to *fuel cells (on hydrogen)* Japan owned 60% of all patents, the US 14%, Germany 7%, South Korea 7%, China 3%, Canada 3%, the United Kingdom 2%, and France 1%.

From this overview one learns that again and again the same countries seem to have patented a lot of know-how in renewable energy.

With regard to capital investments, the figures are moderately different dependent on the sources one uses, and the way in which one defines a domain. Often the best indicator of investments in renewable energy, is to look at the figures official bodies publish on ‘*cleantech*’ or ‘*clean technology*’. Internationally this is often accepted as a useful indicator. Between 2003 and 2008, the production of energy, the conserving of energy and energy-efficiency constituted about 60% of all investments in the *clean tech*-industry in the United Kingdom. In Israel this figure was 85%, and in France 80% for the same period. In general, all aspects of renewable energy in Europe constitute about 75% of all investments in the *clean tech*-industry.

Based upon the *2008 Annual Review and 4Q08 Investment Innovation* of the Cleantech Group LLC in 2009, the following countries are the most important investors in the world in *clean* technologies (see Table 2.1):

As regards the leading companies in the sector, the following countries were important in 2008:

- *American companies* (Sharp, SunEdison, SunPower, EverGreen Solar, General Electric, Tesla, Quantum Fuel Systems);
- *Canadian companies* (Ballard Power Systems, FuelCell Energy, Dynetek Industries Ltd.);
- *German companies* (Enercon, Nordex, Q-Cells, Conenergy, SolarWorld, Siemens);
- *Spanish companies* (Gamesa, Acciona, Isofotón, Iberdrola);
- *A Danish company* (Vestas);
- *Japanese companies* (Tokuyama, Kyocera, NEC, Sanyo, Toyota, Honda);
- *An Indian company* (Suzlon);
- *Chinese companies* (Suntech, BYD).

In its most recent 2017 report, the Cleantech Group LLC has created a new geography of the *top ranked* cleantech companies in the world. The United States is still on top of the world with 51 companies (of which 31 in California), Canada has 11, France, Germany and the UK each boast 7 leading cleantech companies, Israel has 4, the Netherlands has 2. Then follows a list of countries which each have at least one leading cleantech company; Belgium, Finland, Ireland, Norway, Sweden, Kenya, Tanzania and South Africa. Western companies still seem to dominate the cleantech scene.

Taking all factors into account, it is however interesting to note how active Asia (and more specifically Japan, India, China, South Korea) is becoming in the domain of renewable energy and venture capital. What is also interesting from a geopolitical and geo-economical point of view, is that many companies in Asia are trying to position themselves in niches in which they can generate added value. As the old economy will gradually be replaced by a new, greener economy, Asia will thus be able to take a more strategic position. In other words, one could today already speak of a *certain geo-economic power shift* in favour of Asia. An extra advantage is that countries such as China and India have lower costs for the assembly and construction of renewable energy projects, that is why they are sometimes more faster and competitive compared to companies in e.g. Western Europe. From a geo-economic and geopolitical point of view, already for several years Western countries in the OECD group demand a '*level playing field*' with Asia in terms of tariffs and non-tariff obstructions to the Asian markets. Interviewees in the sector of

Table 2.1 Total capital investment in clean tech

Country	Total capital investment in *clean tech*
United States of America	5.6 billion US dollar
United Kingdom	974 million euro
Germany	544 million euro
China	430 million euro
Ireland	423 million euro
Spain	288 million euro
India	277 million euro
Israel	247 million euro
Norway	188 million euro
Sweden	156 million euro
France	120 million euro

Source Cleantech Group LLC, 2008 Annual Review

the solar industry raise the question whether the competitive conditions upon which Asian countries work, are correct. China produces "cheaper photovoltaic solar panels" (PV) with which they could in time flood the market, but do these reflect the real price? First, one can observe that the Chinese government invests substantial amounts of capital in PV. Second, there exists a distorted exchange rate between the yuan on the one hand and the euro and dollar on the other hand, which according to critics does not reflect the "real" economic position of China. Many of the advantages in efficiency within the sector PV which exist in Europe and the US are thus nullified. Thirdly, the labour cost in China is low while the price for electricity remains relatively cheap, exactly because China has so many energy plants working on coal… Interviewees think policy officials should strive towards measures and arrangements with countries such as China in order to remove the trade imbalances, but this will be a long term effort. Interviewees also state that in the PV-sector, real innovation still rather remains an OECD-story. What Asia does best is applying existing technologies in larger scales. This is true in the solar energy sector, but also in the wind energy sector. With regard to Asia, Japan is the exception to the rule. With Japan, most other OECD countries have a genuine level playing field, and can enter the Japanese market, although in itself the Japanese home market for renewables is rather limited compared to other countries in Asia.

In its most recent 2017 report, the Cleantech Group LLC states that Asian Investors are increasing their investments in non-Asian top-100 clean tech companies. That trend seems to become stronger every year; Asian equity investment is steadily increasing. As the 2017 report rightly states, one point is that Asia has strong demand for technologies that address acute needs and problems of the not so far away future. A second one is that, at stake here in the ongoing transition of industry, is the future competiveness for multi-national companies and countries: "*No wonder, therefore, to see corporations as the most dominant investor type in this sample. Japan was the more dominant source of such investors, but China (and* *certainly if looked at through the "Greater China" lens) is now starting to dominate.*" Energy storage and batteries have been high on the activity levels of Asian based investors.

According to Sainteny, the awakening '*geopolitics of renewable energy*' will structure itself around three geographical zones and three thematical playing fields (Sainteny 2010, 114). The three geographical zones are the European Union with Germany as a core country, the United States of America and Asia (with China, India, South Korea and Japan as core countries). The three thematical playing fields are: (1) the control over the technologies which have to be developed further, and the division of the added value these technologies will generate, (2) diminishing energy dependence, and (3) the impact on national development models in the post 2012-era of climate policy. These last two thematical playing fields urge policymakers to invest more in renewable energy so as to realize win-win-scenarios. The most 'exciting' geopolitical game will however play out in the first domain, the "control" over the technologies that are to be developed further. With regard to '*downstream*'-activities in renewable energy, the European Union and the United States of America are still dominant. One can expect that this general head start can be retained for a while longer, although the developments in Asia can go fast. If the US and the EU are to retain their position, then it will become necessary to invest much more in all facets of renewable energy. In the United States of America, often a triple approach is utilized; "*research/capital investment (including in demonstration projects)/start-up of new companies*". Europe often gets stuck in phase 1 or 2. Within Europe, Germany succeeds best in trying to activate its research community, firms and SME-network in structurally linking together the three phases.

On the front of investments in research, one can detect serious differences both through time and between different countries. The share of research into energy questions compared to the total research budgets has dropped in the IEA-member states (OECD countries) from 11% in 1985 to 3% in 2006. The average company in Europe invests only 3% of its turnover into research (compare to the cell phone industry, where this percentage lies at around 15%). This is why more public-private partnerships in renewable energy research are so important in the near future. After the economic crisis in 2008, the energy prices for fossil energy collapsed. As a result, investments in renewable energy technologies suffered for several years. Nowadays they are recovering again, thanks to their growing efficiency as a result of new technological breakthroughs.

In their article "*Financing Innovations for the Renewable Energy Transition in Europe*" published at the end of 2016, Bointner Pezzutto, Grilli and Sparber have created predictive scenarios of public investment in renewable energy research and development in Europe based on this historical dataset and current trends (Bointner et al. 2016). Herein, they present several figures and scenarios which offer insights concerning the EU R&D expenditures from late 1980s until 2030. Here some of their very interesting conclusions:

- Investments in research and development for renewable energy sources will probably increase in the future, largely driven by the European Union 2020 climate targets, and the European Union 2030 framework for climate and energy policies. Renewable energy sources are expected to grow more important for the European Union Member States and the European Commission, creating an expected knowledge stock for renewable energy sources of 12–21 billion EUR in 2030.
- The increases in spending from both Member States and the European Commission, demonstrate the importance of achieving energy independence, which could bring several advantages to European society in terms of declining energy costs, job creation, etc.
- As of 2014, the cumulative knowledge stock in renewable energy sources created by public research and development expenditures was 6 billion EUR for the European Union Member States and 1 billion EUR for the European Commission. The largest share of the knowledge stock is in bioenergy, with an estimated value of 3 billion EUR. Photovoltaics follow with approximately half of the research and development budget of Bioenergy. Solar heating and cooling, wind energy, concentrated solar power, and renewable heating and cooling, are all tied for third with around 1 billion EUR. Other and unallocated renewable energy sources have a knowledge stock of around 400 million EUR. Ocean and geothermal energy are second to last, with approximately 200 million EUR. Hydroelectricity is last with less than 100 million euro (Bointner et al. 2016).

According to a new report by the Brookings Institution, the number of patents issued in the US in fields related to cutting carbon emissions climbed from 15,970 in 2009 to approximately 35,000 in 2014 and 2015, before slipping back slightly to about 32,000 in 2016 (Saha and Muro 2017). The conclusion of the report is very revealing; it states that given the size of the global clean energy economic opportunity, the United States can ill afford to relinquish its lead on innovation in the burgeoning global cleantech market to China or other countries. According to this report, Congress should set aside the skinny budget and draw on years of bipartisan support for energy innovation to coalesce around a core list of minimum viable supports for low-carbon innovation and growth. Most crucial will be provisions to maintain clean energy R&D appropriations at viable levels; maximize the impact of the nation's 17 national energy laboratories; and preserve the Advanced Research Projects Agency (ARPA-E) while maintaining and scaling up the nation's energy innovation hubs and institutes: "*States and regions can and must step up to invest more robustly on their own in low-carbon innovation, just as must the private sector, which must argue more forcefully for essential federal supports even as it moves to shoulder more of the burden itself*" (Saha and Muro 2017). There are clear signs other world powers are catching up. If the US does not compete with them, it could thus affect its long term power position.

2.4.2 The Potential of Renewable Energy Sources and Their Geopolitical Consequences

According to Professor Marianne Haug[4] of the University of Hohenheim, in Stuttgart, the transition in the direction of '*renewables*' creates at least five geopolitical challenges:

1. Imbalances in the locations where these sources can be developed (a problem very similar compared to conventional energy sources);
2. Traditional biomass linked to problems of poverty, health and gender;
3. Hydropower and its disruptive effect on its surroundings;
4. "*New renewables*"—solar, wind, geothermal, waves and tides—the question of central vis-à-vis decentral production;
5. The challenges of a sustainable bioenergy sector—is this feasible?

Current technologies in renewable energy only capture a fraction of the available solar energy, wind energy, biomass, geothermal energy, ocean thermal energy, wave energy and hydropower, as Fig. 2.2 shows very interestingly:

Next to the technological factor, also the geographical factor is at play. Potential geopolitical tensions, solutions, or potential for cooperation is linked very specifically with each type of renewable energy, and also with the natural resources which are available in a country. We already referred to Daniel Deudney's concept of the '*geo-technical ensemble*'. The new technologies that are developed together with the geographical opportunities and limitations of certain geographical areas, will determine the new geopolitical context within which countries, regions and territories will be able to operate, create welfare and wellness, and develop a *power base*—literally but also figuratively. As it is the case in the 'Geopolitics of Conventional Energy', also the 'Geopolitics of Renewable Energy' creates geo-technical opportunities and limitations. Countries are most successful if they can maximize the opportunities while reducing the importance of the limitations as much as possible.

Every energy source has its own specific characteristics and creates its own '*geo-technical ensemble*' which generates an impact upon the macro-regional and international relations. In a world in which renewable energy would dominate as the most important source of energy, those relations could potentially be very different as compared to a world dominated by conventional energy. Moreover, the network of dependencies will be considerably more complex in a renewable energy world,

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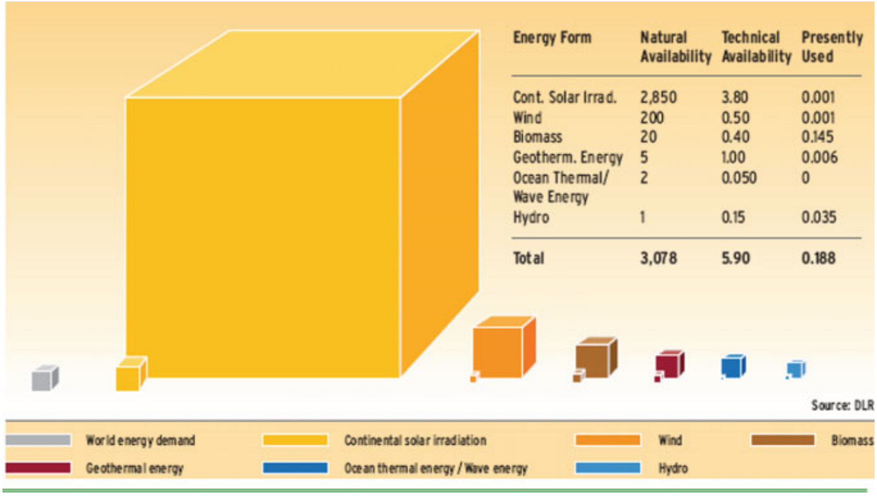
[4] Marianne Haug is among others president of the Board of Directors of the '*Forum für Zukunftsenergien*' in Berlin, an independent think tank on energy policy. She is also member of the advisory group *OMV Future Energy Fund*. For the European Commission, she is president of *AGE7—Advisory Group for Energy for the 7th Framework Programme* and member of the *High-level Advisory Council for the European Technology Platform on Hydrogen and Fuel Cell*. Between 2001 and 2005, she was Director in the *International Energy Agency* (IEA) in Paris, responsible for the '*Office of Energy Efficiency, Technology and R&D*'.



Energy Form	Natural Availability	Technical Availability	Presently Used
Cont. Solar Irrad.	2,850	3.80	0.001
Wind	200	0.50	0.001
Biomass	20	0.40	0.145
Geotherm. Energy	5	1.00	0.006
Ocean Thermal/ Wave Energy	2	0.050	0
Hydro	1	0.15	0.035
Total	3,078	5.90	0.188

Source: DLR

Fig. 2.2 Renewable energy potential versus how much of it is captured by current technologies. *Source* Haug (2008)

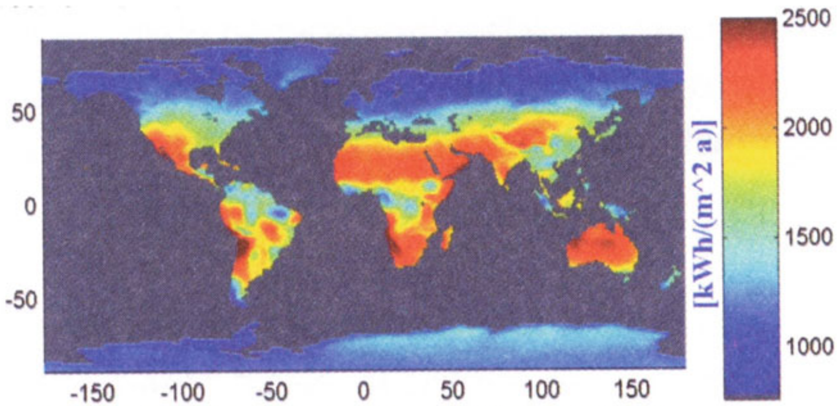
exactly because different types of renewable energy create their own specific '*geo-technical ensemble*'. And to make matters even more complex, these relations can be susceptible to new advancements at the technological front. Hereafter, we will briefly "zoom in" to the potential in renewable energy domains such as solar, wind and biomass, and their geopolitical consequences.

A last element which is sometimes forgotten, is that more renewable energy in the energy mix sometimes may create *new* dependencies upon the outside world for natural resources such as lithium (which is being used in batteries of electrical cars), or silicium (which is being used in solar panels). This entails an unexpected geopolitical side effect of the rapid growth of renewable energy. Hereafter we will briefly study some of these developments.

2.4.2.1 Solar Power Potential and Its Geopolitical Consequences

Certain areas in the world are much more interesting to 'harvest' sun light then others because the number of sun hours in the world is higher each month or because the sun shines with a greater intensity. The following world map by Haug (Fig. 2.3) shows this more clearly:

The map by Haug shows a belt beginning in California over Mexico, crossing the Sahara desert over into the Middle East and then going into Central Asia. Also Southern Africa and Australia clearly are on the map. These regions are ideal to invest in solar energy. Another, more accurate map in Fig. 2.4 provides a better overview of solar insolation in hours:



SOURCE: Meteorological data form European Centre for Medium Range Weather Forecast (ECMWF), ISET/IPP, 2000

Note: Values (in kWh per m² and year) are given in terms of global horizontal irradiation (1983 to 1992).

Fig. 2.3 Solar power potential and solar irradiance (1). *Source* Haug (2008)

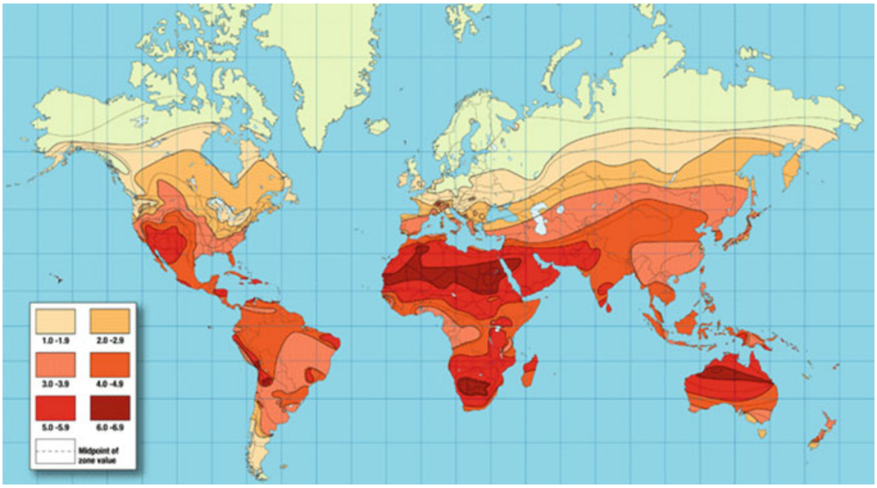


Fig. 2.4 Solar power potential and solar irradiance (2). *Source* http://www.scorigin.com/diy_-_solar_power

From a geopolitical point of view, it is not so difficult to imagine what kind of relations between producer, transit and consumer countries might be developed provided the necessary power lines are invested in. In the Americas it might bring about a closer cooperation between Mexico and the United States of America for example. California and its neighbouring states could be transformed into a power house. In South America one could also imagine interesting new cooperations between countries, although the terrain will make it difficult to actually build the necessary power lines. Between Europe and Northern Africa and the Middle East, an interesting geopolitical and geo-economic relationship might develop. The failed Desertec project which we mentioned earlier tried to take advantage of this. In Asia, India may very well be able to cover its own needs, although China's territory only offers possibilities in very specific regions.

In the northern hemisphere, countries such as Canada, the Nordic countries in Europe and the Russian federation will not be very big players in the solar energy market. They will have to invest in other niches of renewable energy.

The Middle East might be able to retain part of its position as an energy producer. In fact, we see interesting developments in the region on this issue. All countries in the region have excellent possibilities with regard to solar power, with values between 4 and 8 kWh/m. The sun is positioned higher in the sky and clouds are less numerous compared to e.g. Europe. Both *concentrated solar power* (CSP) and *photovoltaic panels* (PV) have a good *return on investment* here. The most important country of all for the moment in renewable energy technologies in general is the United Arab Emirates (UAE). One of the most prominent initiatives is the '*Masdar initiative*', the creation of the first CO_2-neutral city in the world, in Abu Dhabi. Best available technologies are being implemented there. The project combines waste management with renewable technologies such as solar and wind. Also energy efficiency is part of the concept of 'Masdar'. The UAE also plans building gigantic energy islands off the coast, based upon solar technology. The concept was tested in the region a few years ago by Dr. Thomas Hinderling of the *Swiss Centre for Electronics and Microtechnology* (CSEM). With projects such as these, the UAE may very well become a very important player indeed. On the other hand, one notices that countries such as Saudi Arabia, who have large oil reserves, are somewhat lagging behind compared to some smaller countries in the region.

Another country in North Africa which is embracing solar energy is Morocco. The country is investing 6.6 billion euros in the next years into solar projects. By 2020, Morocco will have five solar energy power stations operational, enough to cover 20% of the country's energy needs. Morocco poised to become a solar superpower. In 2015 the country decided to install the world's largest concentrated solar power (CSP) plant, set to help renewables provide almost half the country's energy by 2020. The relative internal stability of the country compared to some other countries in Northern Africa may well result in Morocco becoming an important player, also because of its interesting location not so far from Europe. Hence, one can see that solar power can potentially create new and interesting shifts in geopolitical power relations for those countries who have the potential and invest in it.

2.4.2.2 Wind Energy Potential and Its Geopolitical Consequences

The map in Fig. 2.5 offers an interesting idea of wind power potential in the world:

Wind energy at roughly 7 meters/second (m/s) and faster are economically worth exploiting today even in higher-cost offshore locations; those are the orange, pink, and shades of red and brown in the figure above. In many areas, especially on

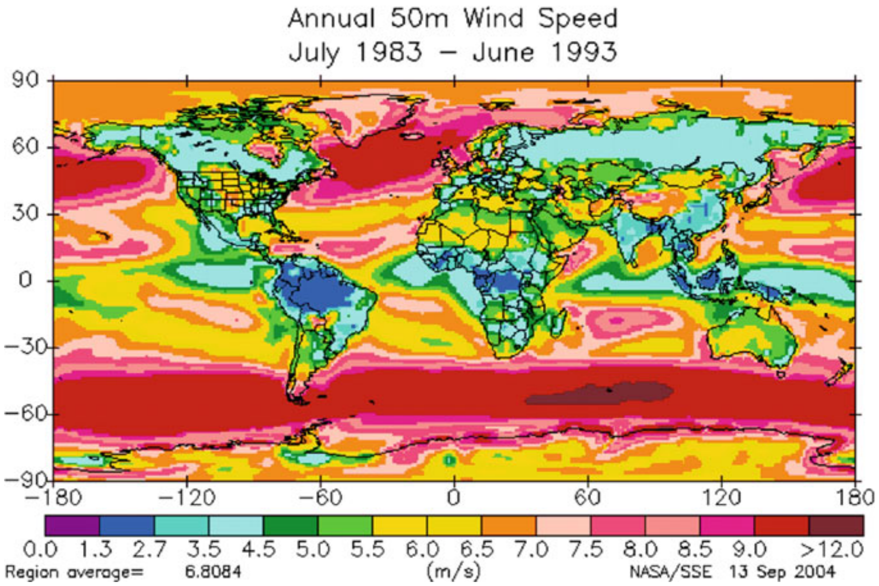


Fig. 2.5 Wind power potential in the world. *Source* http://www.ceoe.udel.edu/windpower/ResourceMap/index-world.html

land, the 6 m/s areas are already economically viable, those are the yellows. We see that the largest wind resources are above the oceans and mid-continental plains of each of the major continents. The coastal oceans are of special interest because they have strong winds and they are close to most of the world's population and electric use. How much of the vast ocean wind resource is likely to be tapped? Offshore wind towers available today are rated to 20 m water depth (some manufacturers say 30 m). Designs now under development would extend this to the entire continental shelf areas (up to 150–200 m depth).

If we look again at the data above with a geo-economical and geopolitical lens, then one could state that of all renewable energies, wind is most dispersed. However, when one looks at the areas in the world which are more economically viable compared to other regions, another picture arises. Central America and a big part of South America seem to be the biggest losers with regard to wind power energy. The same can be said for Central Africa and Indonesia. The reason is quite straight forward; because they are at the equator (see also Troen and Petersen 1989).

Other parts of the world are more interesting with regard to wind energy, but the situation within each continent is very specific indeed. Let us now briefly look at Europe in Fig. 2.6:

In the Mediterranean, only the shores of the coast of southern France are interesting for wind energy. The same can be said for some islands in the east of Greece. The most potential can be found in the North Sea. It is therefore not a coincidence that the European Commission proposed a *North Sea Countries*

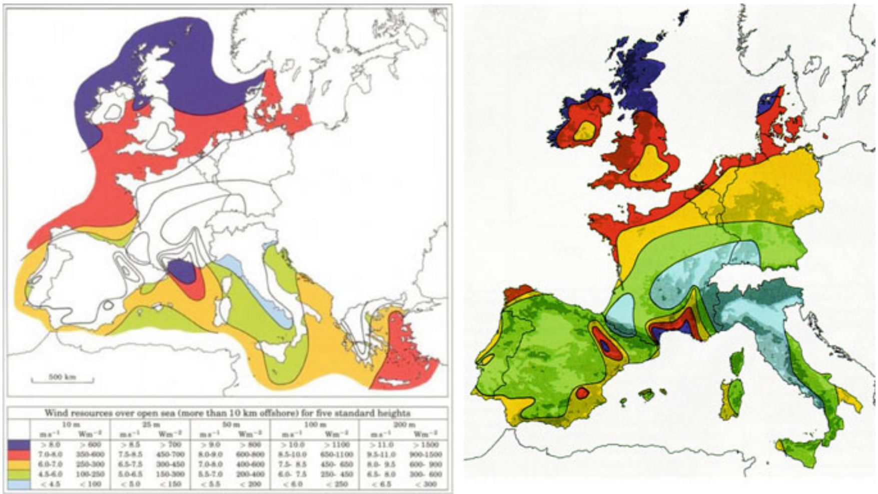


Fig. 2.6 Wind power potential in Europe. *Source* http://stro9.vub.ac.be/wind/windplan/; http://www.all-creatures.org/hope/gw/GD_wind-offshore_potential_Europe.jpg

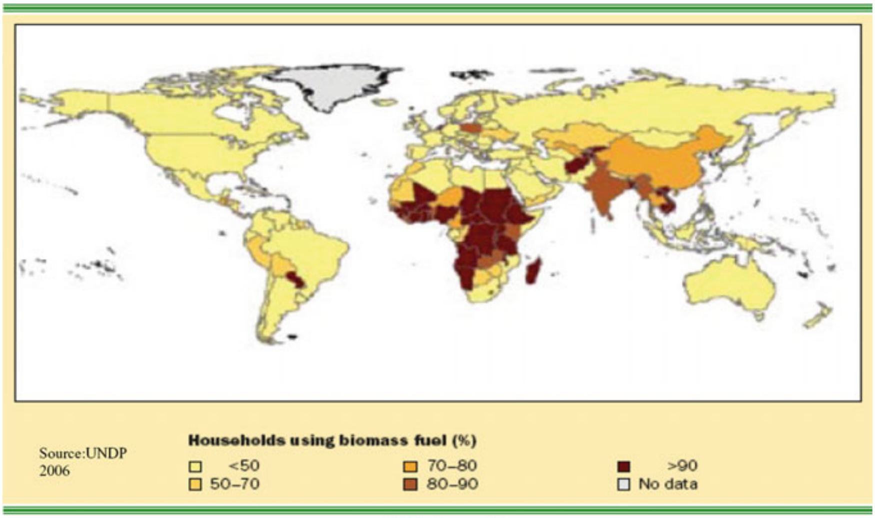
Offshore Grid (see supra). What especially seems important from a geopolitical and geo-economic point of view, is the interconnection between this project and the European mainland.

2.4.2.3 Bio-energy Potential and Its Geopolitical Consequences

In first instance, biomass does not seem as ‘sexy’ as other sources of renewable energy. Its applications are multifarious, that is why biomass is much more difficult to capture in its potential from a geo-economical and geopolitical point of view. Who says biomass, may think of biofuels. This may immediately spur debates on the deontological questions regarding biofuels and their competition with the food production. However, this reflects only a fraction of the story, biomass entails much more than this. Biomass has many different manifestations. Not using biomass would be like excluding a very important source of renewable energy.

Biomass can make an important contribution in geo-economical and geopolitical terms to reducing poverty in the world (see Fig. 2.7). As Haug indicates, many households in the world, and especially in Africa and Asia use biomass as their most important source of energy, but not in an efficient way. Modern biomass-stoves and similar more efficient technologies, could become ‘*game changers*’ in the developing world. Some groups such as *BioPact* make a plea for a geopolitical cooperation, “a green energy pact”, between Europe and Africa.

A more detailed map on the usage of biomass in households can be found in Fig. 2.8:



© Marianne Haug

Fig. 2.7 Households using biomass fuel (%). *Source* http://news.mongabay.com/bioenergy/site/goals.html

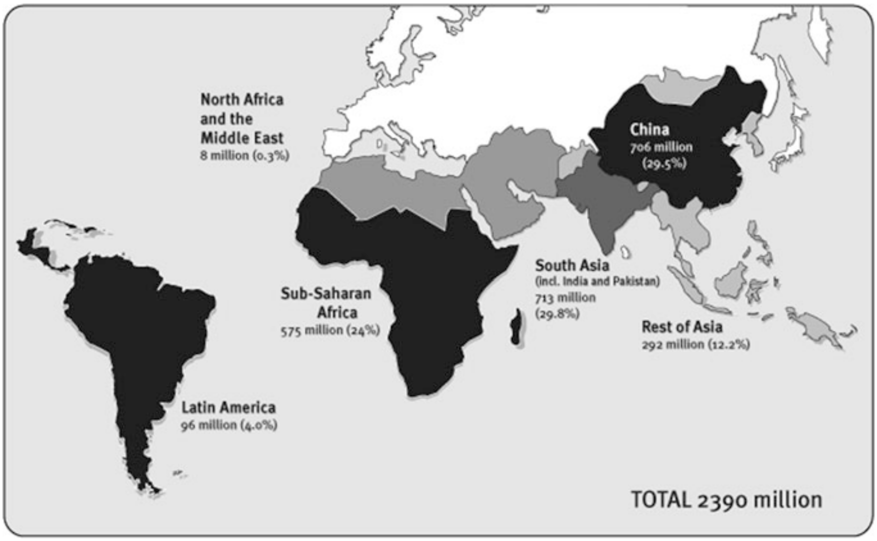


Fig. 2.8 Usage of biomass in households. *Source* http://practicalaction.org/smoke_report_2

But this is not the only aspect of the *Geopolitics of Biomass*. Some claim that a biomass-revolution is at hand. Central in this is the idea that the current economy focuses too much on fossil fuels and conventional energy sources. These are not only used in transport, but also in many products which we use in daily life. Oil is for instance also used in fertilizers. The industry which makes this all happen is the petrochemical industry. The big petrochemical clusters in the world, e.g. in Houston, Texas (ranked first in the world) or in Antwerp, Belgium (ranked second in the world), will in the coming decades come under pressure. For each of the products that they produce, alternatives will have to be found which are not based upon oil, but rather based upon biomass. This suddenly places biomass centre stage in the international energy regime of the future.

One of the leading countries in the world with regard to the *bio-based economy*, is the Netherlands. In October 2007, the Dutch ministry of Agriculture, Nature and Food Quality published the document '*Closing The Chain*'. In it, the government vision is presented on the role the *bio-based economy* can play in the green transition in the Netherlands. Some of the pillars are: the efficient use of biomass via biorefinery (the unravelling of biomass into green raw materials as the base for a wide diversity of products), sustainable production of biomass worldwide (for which specific criteria are developed), the production of green gas and sustainable electricity. Next to this, the government sees it as its task to reduce the risk of a possible competition with the food production. Even more important is that the Dutch sector of the petrochemical industry has defined the goal in twenty years' time of having 30% of all its applications based upon biomass instead of oil. In the Netherlands, a process has started to bundle all existing competences and create a *Biorefinery Cluster*. The Netherlands has special assets with regard to the biomass-revolution, especially in the combination of its logistical role with its technological expertise and its agricultural tradition as second exporter in the world. The Netherlands' case also shows that in the biomass-revolution, a special role will be assigned to the harbours. In this regard, Rotterdam, Delfzijl and even the Belgian harbour of Antwerp are mentioned as possible hubs in biomass trade in the world. Some even plea to install a world exchange in biomass in the Netherlands and Flanders. In the past, our former Flemish Centre for International Policy showed that Flanders (the northern part of Belgium) and the Netherlands are quite complementary as regards to know-how in biomass, which could be the basis for a further cooperation between these two entities. Currently, this is further being explored at the diplomatic level between Flanders and the Netherlands.

The transition towards biomass will be knowledge-intensive. This will mean that a lot of investments will be needed to make biomass a more efficient and applicable source of energy around the world. Only certain industrial centres in the world are currently equipped to deal with this transition, whereas other parts in the world—often in the southern hemisphere and in Russia—have a strong position in the fact

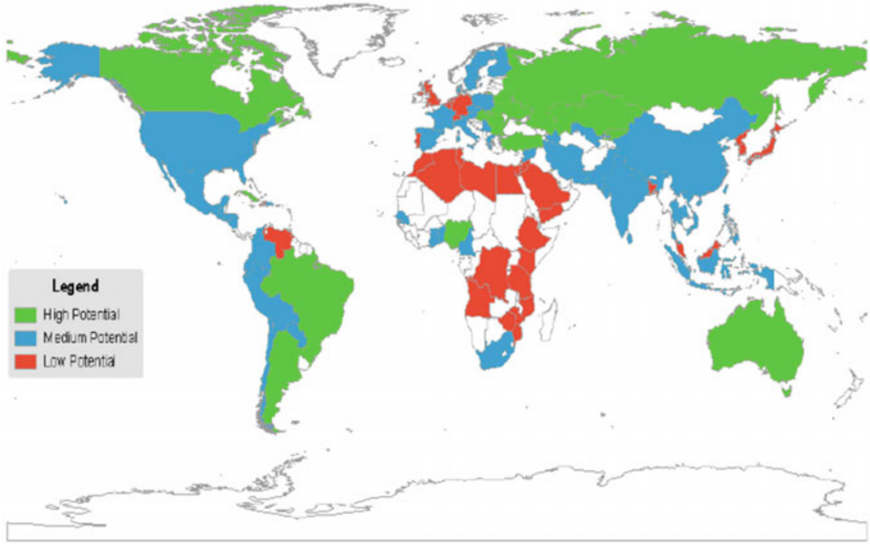


Fig. 2.9 Potential countries have with regard to biofuels. *Source* IFPRI (2008)

that they have the biomass themselves. New relations between importer and exporter countries will thus arise and shape the Geopolitics of Biomass. However, there is a danger of new dependencies.

With regard to *biofuels*, similar concerns can be raised which could influence global geopolitical and geo-economic relations. Figure 2.9 developed by the International Food Policy Research Institute (IFPRI), offers an idea of the potential countries have with regard to *biofuels*:

Among the potential leaders with regard to the export of biofuels, the following countries can be mentioned; Brazil, Argentina, Canada, the Russian federation, Turkey, Belarus, the Ukraine, Kazakhstan, Uzbekistan, Romania, Hungary, Australia and Nigeria. If these countries invest in biomass and biofuel applications, then they could become actors which play a role in the geopolitical relations which will be shaped around biofuels. Today, we can already detect a fierce competition between the United Stated of America and Brazil for a *control over* and more importantly *access to* markets—which already is played out at international fora such as the World Trade Organization. Often this 'battle' is fought via technical measures and standards.

Back in 2006, the International Energy Programme of the Dutch Institute for International Relations 'Clingendael' published an interesting study on '*Future Fuels and Geopolitics: The Role of Biofuels*' (Van Geuns 2005). In this document, bioenergy and *biofuels* are seen as important so as to bridge the energy gap which many countries will experience. Especially bio-energy is important from a geopolitical point of view, since it can be produced locally. The import-portfolio of countries producing it will change, and they will become less dependent upon fossil fuels. It will also foster the scientific and technological development of these countries, and stimulate international trade. Biofuels are more easy to implement because the adaptations which have to be made on an infrastructural level are less sizeable compared to electrical cars or cars on hydrogen. Bioenergy also clearly affects the geopolitics of energy. Regions with a high production potential for bioenergy can gradually decrease their dependence from the Middle East and unstable countries in the world (e.g. Nigeria) and become themselves exporters of energy. Regions with a lower production potential for bioenergy will have to develop other strategies.

The Clingendael International Energy Programme also referred to studies of the *IEA Bioenergy Task 40* in order to identify some potential ‘winners’ and ‘losers’. According to these projections, Sub-Sahara Africa seems to encompass the biggest potential with regard to bioenergy, closely followed by South America and the Russian federation. The European Union and the United States of America are in the ‘middle group’, and could become potential biofuel-importers. Asia seems to be a more complex story; East Asia in general and China in particular have a clear potential, there where Japan finds itself in a less comfortable position. Southeast Asia in general and India in particular have a clear potential, but this is not in proportion to its rapidly growing population. Australia and the islands in the Pacific Ocean will probably become major exporters, six times more than their domestic consumption. The biggest loser in the story of bio-energy seems to be the Middle East. But the Middle East does not necessarily need bio-energy. In our opinion, these projections can considerably be influenced by the degree to which countries may succeed in developing specific technologies, and link these to innovative sales strategies. Also important is whether the countries will be vigilant in detecting trade obstructions. Nevertheless, from a geopolitical point of view, biofuels and bio-energy will probably offer important chances to parts of Africa and South America (Slingerhand and van Geuns 2006; Slingerhand et al. 2008).

With biomass, there is now a new chance—the first real one in 200 years—to strengthen the economic function of agriculture in national and regional economies. For two centuries, agriculture has decreased as a percentage of the economic activity in places across the globe. The transition towards biomass and bio-energy creates a new role for agriculture, not only in the production of food, but also in energy and raw materials for a biobased economy. With biomass, the energy production and consumption could be again brought into a balance. In the long term, this may lead to more autonomy in terms of energy or energy security. A new international import- and export market may be developed, and certain countries and regions may play a pivotal role in this.

2.4.2.4 Electric Cars, ‘Renewables’ and the Rising Geopolitics of Rare Earth Materials

Up until now, this chapter identified some potential positive aspects of the transition towards renewable energy. However, there is also another side of the coin. Ryan Hodum wrote in his article ‘*Geopolitics Redrawn: The Changing Landscape of Clean Energy*’ about another, less benign aspect of the transition towards renewable energy systems; the Geopolitics of Rare Earth Materials (Hodum 2010). Notwithstanding the progress that has been made, significant problems remain. The production of wind turbines and electric vehicle batteries is dependent upon rare earth materials, which raises concerns among technology developers and national security planners. Wind turbines are among others composed of steel, concrete, magnetic materials, aluminium and copper. The magnets used in wind turbine gearboxes require *neodymium*, a rare earth element. The increasing demand for neodymium may strain production and lead to dependency on insecure supplies. The world’s largest rare earth deposits are situated in China. Around 90% of U.S. rare earth imports come from China.

Just as demand for rare earth elements needed to produce sophisticated electronics is exploding, China—which has a monopoly on supply over the rare earths—has in the past tried to cut back on exports. In order to do this Beijing cited *industry restructuring* and *environmental concerns*. In 2010, Beijing slashed export quotas by around 40% from 2009 levels, saying it must protect its reserves that have been recklessly exploited over the past 20 years. Government officials contend that with one-third of the world’s known reserves of ‘rare earths’, China has satisfied more than 90% of the world’s need for those elements (Becker 2010).

The 21st Century Economic Herald newspaper, stated the following in 2010; “*China is the land of rare earths in the same way that the Middle East has oil and Australia has iron ore. But China has not enjoyed the handsome profits that those countries have ripped from their control over precious resources*”. Former Chinese leader Deng Xiaoping said once during a tour of China’s export zones in 1992: “*The Middle East has oil*, *China has rare earths*”. Beijing has repeatedly denied that it would use its dominance of this crucial industry as a “bargaining tool” with rival nations. Hillary Clinton, U.S. Secretary of State, stated in October 2010 in Hanoi that she had received assurances from her Chinese counterpart, Yang Jiechi, that Beijing had “*no intention of withholding these minerals*” from the world market. However, the question remains a sensitive one.

With electric vehicles, not only the abovementioned rare earth materials are problematic, but also the lithium used in lithium-ion batteries. Half of global lithium reserves are located in Bolivia, though they are not yet economically recoverable. The majority of the world’s recoverable reserves are to be found in neighbouring Chile (Hodum 2010).

Also China has important lithium reserves, which it is using strategically. It is not a coincidence that China is developing electric cars. One of the big companies in this new car sector is BYD (‘*Build Your Dreams*’), a company from Shenzhen, in the southeast of China. It was set up in 1995. BYD originally started with the production of Lithium-ion batteries, and in 2005 diversified into electric cars. In a very short time it became an important player. In October 2016, BYD became the world’s second largest plug-in electric passenger car manufacturer with more than 171,000 units delivered in China in one year. A similar company with an equal amount of know-how is the Japanese company Nissan. In the past, Nissan tried to sell its electric car on the Chinese market, the only market in the world where it would be possible to a sell relatively high volume in a short time (Nissan aims at 400,000 a year). An important asset is this is Nissan’s own Lithium-ion battery. But, in order to produce this car in China, it needed to have access to the Chinese Lithium-supplies. Japan does not have as many supplies. The Chinese government does not allow foreign players to alone develop activities with regard to the electric car. The access to the Lithium-mines was blocked for Nissan until it agreed to set up a *joint venture* with a Chinese partner, promising also a technology-transfer. The story on the electric car in Asia thus transforms into a tale with a geopolitical nature; a battle for the access to raw materials linked to know-how on battery technology. Today, China is clearly protecting its own market in electric cars so as to be in better shape to sell cars tomorrow to the US and Europe. All this produces a new picture of the transition to renewable energy, which isn’t always as benign as thought in advance. In September 2016, the Renault-Nissan Alliance hit a milestone of 350,000 electric vehicles sold, through which it maintains its position as global electric car manufacturer. Without its alliance with China, that would have been impossible. Figure 2.10 offers an overview of the world’s lithium supply:

On the other hand, solar photovoltaic panels require among others indium, gallium, germanium and silicon (Hodum 2010). The US depends completely on foreign gallium and indium, and for over 80% on germanium. In addition to China, these materials are also located in Central Africa and Russia. The *Geopolitics of Renewable Energy* may in this sense look more similar compared to the *Geopolitics of Conventional Energy*; whereas the West might be trying to wane its dependence on e.g. the Middle East, new dependences may be developed, for instance on Chinese minerals…

Of all the countries in the world, the United States of America are among the first countries to develop a *Critical Materials Strategy* with regard to clean energy components (U.S. Department of Energy 2010). However, even with such a strategy in place, companies such as the electric car manufacturer Tesla have to adapt to today’s realities. Tesla is highly dependent on China in two ways; it needs access to its lithium deposits and consumer market in order to sell its cars. Recently in 2017 China and Tesla made a deal; technology transfer in exchange for access to lithium. Japan’s Panasonic, a Tesla battery supplier, is now also active in China and

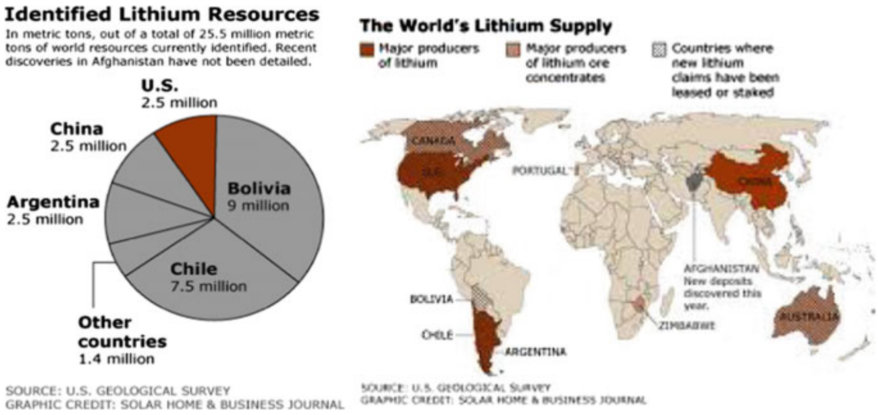


Fig. 2.10 Overview of the world's lithium supply. *Source* Coyle (2010)

will further expand its activities there. The deal is not unlike a similar one between Japan's Nissan and China. This Beijing strategy has meant that China is able to leap frog the technological curve. Its own electric car manufacturer, BYD ('Build Your Dreams'), is growing extremely fast. The latest figures are staggering. According to Desjardins, global lithium-ion battery production will increase by 521% between 2016 and 2020. By 2020, all lithium-ion battery production will still be concentrated in only four countries; 66% in China, 22% in the United States, 13% in South Korea and only 3% in Poland (Desjardins 2017). Have companies such as Tesla and Nissan sold their soul in exchange for access to China? The strategy of Beijing would mean that the country would become a major power in this technology, and quite probably will be able to jump ahead of the curve. This short case study with regard to lithium-ion battery technology and the electric car proves quite illustrative in terms of geopolitics. If in a post 2040-world, the French and British gasoline and diesel ban would become more universal, our dependency on OPEC countries in terms of oil would be replaced with an even more dramatic dependency on only five lithium resource countries and only three real producer countries of batteries. The question thus must be posed whether future policy officials will not judge such odds to be too dramatic to contemplate in terms of shifting global power relations. Diversifying one's portfolio will also become necessary in this regard. Whereas anno 2017 a growing consensus is mainstreaming that electric cars (with lithium-ion batteries) will be the future, geopolitical realities may soon kick in somewhere in the 2020s. The projected overall dominance of China in terms of both lithium resources and battery production capacity will probably prove to be a risky calculation for Western countries. Geopolitical realities might thus kick in. The lesson from this is that Western countries should invest in a more wider range of potential technologies and not place all their eggs in only one technological basket. If not, the consequences could be dramatic. It would install a major geopolitical dependency that cannot be compensated anytime soon. Diversification in terms of technological investments will thus prove to be crucial in a geopolitics of renewable energy world.

2.4.2.5 Does a Renewable Energy Regime Foster a Multipolar World Order?

One of the most intriguing questions one can ask with regard to the transition to a world with a renewable energy regime, is what impact it will have on the international system.

The conventional energy regime fostered the accumulation of capital and military power, so as to be able to develop oil and natural gas fields. Much of the military power of the United States of America was built in the first half of the twentieth century, when the US was the 'Saudi Arabia' of its time. Equally, the Soviet Union was gifted with a wealth in oil, natural gas and other material resources, which formed the base of much of its economic, military and political power. We can detect for instance a correlation between the high energy prices of the seventies in the last century, and the elevated position of the Soviet Union during the Brezhnev era. In 1945, President Roosevelt grasped the idea that the US eventually would become dependent on foreign oil. He pioneered a foreign policy based on oil, by having a political agreement with Saudi Arabia (security for oil)—to make up for the decline of American reserves. This agreement became a dominant factor in American foreign policy in the decades thereafter. This later culminated in the Carter Doctrine which stated that an attempt by any outside force to gain control of the oil in the Middle East, would be considered an attack upon the vital interests of the United States. In effect, it is not a coincidence that the international oil regime eventually was one of the more important background variables which fostered the development of the international system into a *bipolar* one (Klare 2002, 2005, 2008). During the end of the bipolar system, between 1989 and 1991, oil prices were relatively low (20 US$/barrel), with the exception of the times during the Gulf War (40 US$/barrel). The nineties were years in which the global search for diversity in oil fields produced a stable international regime, a *uni-multipolar* one, led by the US under the banner of 'globalisation'. From the beginning of the 21st century, the smaller oil fields in many areas outside the Middle East gradually depleting. As a result of this, the oil price rose once more and this time more structurally because hundreds of millions of consumers in Asia (India and China) entered the global economic scene. The power of the US gradually declined in relative terms, and the Russian Federation used this period to re-install parts of its international stature in the world. But the bipolar system was no longer in the cards. Henceforth power was more distributed, and one can debate where exactly the world today finds itself somewhere in between a *uni-multipolar order* and a genuine *multipolar one*.

If we agree with the assumption that the oil age has now gradually begun its long decline, which will take more than several decades, what kind of international system will come after this? This book chapter shows that much will depend upon the investments made by countries in renewable energy technologies, but also upon their access to several rare earth materials. Based upon these factors, one could build a strong case that the international system will most likely in the coming ten to twenty years evolve further into a *duo-multipolar system*. This means a world in which power is shared on a more equal basis among different regions in the world, but one in which the United States of America and the People's Republic of China play a pivotal role. For this argument, we can refer to two factors; (1) the research and money currently invested into renewable energy, and (2) the factor of rare earth materials.

First, the research in this book chapter shows the dominance of the US in terms of research money and patents in the area of clean tech. Indeed, the European countries individually also invest a lot of money and know-how into clean tech and renewable energy, but often their efforts do not lead to final products. Of all European countries, Germany has been able to acquire a pivotal position, but this position was achieved at a high cost relatively speaking. Whereas Europe pioneers a lot of projects in renewable energy, it is less clear whether the EU will be able to translate this into a power position. The People's Republic of China is less on the cutting edge of technology and know-how, but does what it does best; marry available technologies in renewable energy with the factor it has plenty of—labour. Since the mid-2000s, Chinese officials have increasingly realised the strategic importance of renewable energy, and have made the decision that Beijing should strategically invest in it. In just a few years, China has already become the world's largest producers in solar energy, wind energy and electric batteries. This gives China a lead over other countries. One can detect similar developments in e.g. India and the United Arab Emirates, but nowhere in the world are renewable energies combined with a deliberate strategy to strengthen the country's position in the world as is being done today by China.

Second, the factor of rare earth materials. A whole range of rare earth materials is needed for renewable energy technologies to work. As the need for these technologies will rise, different countries will benefit from it. China however is uniquely endowed with some of these crucial rare earth materials—for instance lithium, but the same can be said for a number of other rare earth materials. China is deliberately pursuing a policy whereby it wants to protect its own reserves. This creates potential dependencies, and will perhaps force other countries to be more subservient to China's wishes, or export cutting edge technological know-how in exchange. This forms an added argument why China may well develop its position as a power, a position in the world it will probably share with the United States. It might be however, that this period of a duo-multipolar order will again subside in favour of a genuine multipolar one if the technologies are developed in such a way that they are less dependent upon ‘rare earths’. Generally speaking, renewable energies themselves are quite complementary spread across the globe: for instance countries where the sun shines hardest, have less possibilities with regard to biomass, and vice versa.

2.5 Conclusion

This chapter studied the *geopolitics of renewable energy game and its potential impact upon global power relations*. The short answer is that the jury is still out. The complex geo-technical ensemble means that it is too early to really thoroughly grasp the consequences in terms of power distribution between the ‘status quo’ and the ‘revisionist’ states. Not only will it depend on a continued investment by private and public capital, government will also have to invest in a favorable regulatory environment. We have also seen that renewable energy by nature is much more decentralized, which would mean that there are several possibilities to create robust energy mixes, also in a renewable energy world. Key in this all remains the ultimate technological prize of renewable energy storage. Until then, the geopolitics of renewable energy will co-exist will a geopolitics of natural gas. We may thus expect a transition phase of two to three decades within which countries will of course try to defend their own business models. Just as Saudi Arabia currently is trying to slow down its regional natural gas rivals, the same may happen at a later stage with natural gas states who are being confronted by new renewable energy storage facilities that will upscale and come online.

The question was also asked whether the geopolitical world of renewable energy was different or similar compared to the geopolitics of conventional energy. The answer to this question seems to be a mixed one.

On the one hand, the answer could be that it is potentially *different*. Renewable energy is more decentralised in nature compared to conventional energy. An interwoven net of *renewables* combined with smart grids could potentially be more reliant and entails the *potential* for societal rejuvenation in the sense that it could empower people and regional authorities vis-à-vis central governments and interests. Moreover, those countries who invest in renewable energy may well become central players in the future. The US and China, but also some individual EU-countries such as Germany, are actors that invest a lot in renewable energy technology. As renewable energy will grow and gains a higher percentage of the energy mixes in countries, it will also alter their geopolitical positions. Countries which geopolitically enjoy pivotal positions in the conventional energy world, will not necessary enjoy the same position in a world in which *renewables* grow in importance (e.g. Saudi Arabia). Eventually, geopolitical relations across the globe could be affected.

On the other hand, the answer could be that it is *similar*. The bigger projects in renewable energy suffer from very similar security issues as compared to traditional energy projects. The question for instance lies with where certain pivotal power lines will run, and who will control them. What about the physical security of these power lines? In addition, the *Geopolitics of Renewable Energy* also creates geo-technical opportunities and limitations. One of the major problems with which countries will be faced, concerns the issue of the rare earth materials that are needed in the technological advances of renewable energy technology. Rothkopf convincingly wrote that the green geopolitical crises might look similar to those of the conventional energy regime. There might be green protectionism in the western world, but also the condition of oil producing countries might be problematic in a world where renewable energy is growing fast (Rothkopf 2009).

In all probability, the geopolitics of conventional energy and that of renewable energy will exist next to each other for a period of several decades. Decision makers will have to be creative in trying to cancel out the drawbacks of one source of energy with the advantages of the other. In that sense, the geopolitics of energy will become more complex, and will have to deal with a variety of issues in foreign policy, diplomacy and international security. Instead of approaching this issue in *antithetical* terms, one should rather try to pursue more *synthetical* approaches in the study of geopolitics, power transitions and energy.

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Chapter 3
Redrawing the Geopolitical Map: International Relations and Renewable Energies

Karen Smith Stegen

3.1 Introduction

This edited volume avers that, at some unknown point in the future, global energy needs will be met primarily by renewable energies. This chapter's contribution is threefold: (1) apply insights from theories of international relations (IR) to assess how renewable energies might re-shape international politics; (2) suggest a way to peer into this future and surmise, with the data available today, which states might be best posed to become the 'geopolitical winners'; and, (3) explore the types of dependencies that could become problematic in a 'renewable energy world'.

Numerous reasons—many of them interrelated—obtain for why the scenario of a renewable energy-dominated future might come to fruition. Foremost is the threat of climate change, which is primarily caused by the combustion of fossil fuels. As climate change becomes more obvious and the effects become deleterious for ever more people, states will be placed under greater pressure to curtail the use of carbon-producing energy sources in favor of more sustainable forms of energy. Two important developments—which are already underway—are increased support for renewable energy and greater use of renewable-energy-sourced electricity, for example, in heating, cooling, and transportation (See Chap. 1 of this volume; also BMWi 2016). Concomitantly, climate change mitigation will likely lead to decreased support and subsidies for fossil fuels. Second, conventional oil and gas production has already peaked and unconventional oil and gas will also eventually peak, although this could happen in the distant future. However, the costs of recovering and producing unconventional oil and gas will overtake the costs of many forms of renewable energy, which boosts the latter's competitiveness.

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Although there may be some pressure to increase nuclear power generation, there are strong indications that renewable energies will be the preferred sources of energy. Concerns about nuclear safety and waste storage have not abated and public acceptance is low (Verbruggen 2008; Ertör-Akyazi et al. 2012; Karakosta et al. 2013; Park and Ohm 2014). Moreover, geologists debate whether uranium supplies will be sufficient for a global buildout of nuclear power (Dittmar 2013).

Thus, an assumption underlying this project is that eventually humans will live in a predominantly renewable energy world. How energy is produced, distributed and consumed affects both domestic and international politics (Klare 2001, 2008, 2012; Mitchell 2011). Relying on insights from the two predominant perspectives of international relations, (neo)realism and (neo)liberal institutionalism, this chapter posits that, in a renewables world, power and influence will accrue to those states with raw renewable energy potential that are able to attain a high degree of energy self-sufficiency and export dominance. The losers will be the countries that lag behind, still bound to hydrocarbon supplies and enmeshed in asymmetrical supply relationships.

The problems associated with hydrocarbon dependence are manifold. Not only are dependent states vulnerable to manipulation, energy dependence has also affected geopolitical configurations of power and has directly affected the foreign policies of both importing and exporting states. For example, oil revenues have empowered dictators and have facilitated the ability of exporting countries to pursue both unsavory domestic policies and foreign policies that counter the interests of importing states. Oil dependence has also weakened strategic relationships, as some dependent states have been reluctant to challenge states upon which they are energy dependent (Smith Stegen 2014). Moreover, power projection on behalf of energy supplies can result in disproportional military build-ups. For example, according to a Council on Foreign Relations report (Deutch et al. 2006, 29): “U.S. strategic interests in reliable oil supplies from the Persian Gulf are not proportional with the percent of oil consumption that is imported by the United States from that region.” Because of the nature of renewable energies, these issues should lessen as states transition away from hydrocarbons.

The hydrocarbons-to-renewables transition may take decades to unfold, but the trajectories countries opt for now may be decisive in determining whether they head towards renewables in the short- to intermediate-term or perpetuate their reliance on fossil fuels (Haug 2012). To assess which trajectory countries are likely to follow, this chapter utilizes variables that convey the forces within a country that may either *impede* or *facilitate* a transition to renewable energies. As many studies focus primarily on factors facilitating transitions, one of the distinguishing features of this study is the inclusion of possible impediments.

This chapter proceeds as follows: the next section analyzes what it means to be a geopolitical winner from the vantage point of IR theory. The third section examines the forces that work to either impede or facilitate a transition to renewable energies and delineates the variables approximating these forces. In the fourth section, the data collection techniques and methodology are explained, after which the variables are computed to reveal the ‘losers’ and ‘winners’, that is, the countries most likely to have greater self-sufficiency and/or become renewable energy exporters. The fifth section explores the kinds of energy-related dependencies that could emerge with greater reliance on renewable energies. The chapter closes with a discussion of the political implications.

3.2 IR Theory and Geopolitical 'Winning'

What might a shift to a renewable energies era portend for international politics? How might renewables give rise to new 'geopolitics' and configurations of power? IR theories offer several ways of conceptualizing energy as a source of state power and of international tensions and conflict.[1] This chapter focuses on the two perspectives considered the "mainstream" IR theories: (neo)realism and (neo)liberal institutionalism (Pease 2012, 43). Both schools of thought posit that the international system is anarchic—meaning there is no overarching authority governing interstate interactions—and that states comprise the main units of political power. However, the two differ in their concerns and dependent variables as well as in their beliefs regarding the drivers of conflict and the solutions thereof.

For realists, international politics is a realm of struggle as states jockey for security and advantage—and ultimately for survival. Neorealism, also known as structural realism, is a 20th century adaptation of classical realism that attributes conflict and war to changes in the distribution—or hierarchy—of power within the international system (Waltz 1986). Within this system, national power and military power are of paramount importance, and it is primarily changes in a state's capabilities vis-à-vis other states that alter the balance of power and potentially lead to conflict. Power and security, in the neorealist worldview, are relative: if State A has more power and security, then State B has less. Energy access plays a role in that it comprises an integral component of latent power, which can be converted by states into economic and military power, that is, national power (Mearsheimer 2001; Morgenthau 1948; Treverton and Jones 2005). Thus, energy security, defined by the International Energy Agency (IEA 2017) as "the uninterrupted availability of energy sources at an affordable price", is linked with national security.

From the neorealist perspective, the geopolitical winners in a renewable energy world would be the states with the most power and the definitive winner would be the world hegemon, i.e., the state with the most military power. For 'offensive realists', states should attempt to gain as much power as possible and become the hegemon (Mearsheimer 2001), which would mean securing abundant supplies of reliable energy. 'Defensive realists' caution states not to attempt to maximize their power, lest they trigger an arms race, but would agree with offensive realists about

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[1] This chapter explores how IR theories can expand our understanding of energy issues, but discussions about the role played by energy in state power and in domestic and international conflicts have typically been undertaken by scholars of energy security and energy geopolitics, see, for example, Gnansounou 2008; Klare 2001; 2008; 2012; Mitchell 2011.

the wisdom of seeking self-sufficiency in energy. Thus, according to the realist perspective, energy self-sufficiency is considered a component of national power—and presumably part of any geopolitical winner's arsenal. Indeed, some realists have explicitly argued the more energy independent a state is, the better (Krasner 1978). To understand the role played by export dominance, we turn to the other mainstream theory of international relations: neoliberal institutionalism.

Whereas in the realist/neorealist perspective anarchy and intrastate competition are viewed as consistent features of the state system, neoliberal institutionalism—which is a 20th century adaptation of classical liberalism—takes the more optimistic view that certain conditions, such as mutual and symmetrical dependence (also termed interdependence) between states, can have a pacifying effect on intrastate relations (Polachek 1980; Russett and Oneal 1999). Political interdependence, as manifested by international regimes and institutions, particularly creates conditions fostering cooperation (Oye 1992). Some scholars argue that economic interdependence is also conducive to peace, but others have observed that asymmetries in dependence can "provide sources of influence for actors in their dealings with one another. Less dependent actors can often use the interdependent relationship as a source of power" (Keohane and Nye 2001, 10; see also Hirschman 1945).

Under this logic, the less dependent actor in an asymmetrical relationship could use its dominant position to coerce concessions from the more dependent actor, for example, by threatening or actually enacting disruptions to trade. In energy relations, leverage is presumably gained by the actor with the capacity to issue or enact energy disruptions—the so-called 'energy weapon'. The 1970s oil embargo is a classic example (Yergin 1990). In more recent times, Russia has manipulated natural gas supplies—sometimes successfully—for political gain (Smith Stegen 2011).[2] The key here is that asymmetrical supply relationships expose the more dependent state to political pressure. And, this pressure must not necessarily be overtly applied. Indeed, an exporting state may cleverly attribute a disruption to technical problems or weather disturbances, but the timing of the disruption sends a political message, such as Russia's curtailment of gas supplies prior to elections pitting pro-Kremlin candidates against pro-Western candidates (Smith Stegen 2011).

Thus, in the neoliberal institutional worldview, geopolitical winners would fall into several potentially overlapping camps: first, the winners would be the states that are less vulnerable to foreign manipulation by others, that is, they would have greater self-sufficiency/less dependence. Second, they would be the states with sufficient economic prowess to influence or outright manipulate others. In other words, they would have sufficient excess electricity generation to become exporters and could potentially use that export dominance as political leverage.

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[2] This use of 'economic statecraft' tools is not necessarily a negative development. In recent years, scholars have observed that states may turn to sanctions instead of military intervention to influence other states (Hufbauer 2007; Early 2015).

As many scholars have noted, one of the benefits of renewable energies is the ability of countries to deploy local and decentralized energy sources (Scholten and Bosman 2016). Because all countries have at least some potential for renewable energy generation—for example, from wind, solar, geothermal, or the ocean—it can be expected that, in a predominantly renewable energy world, more states and regions will be energy self-sufficient. This has several implications: first, there might be less opportunities for ‘energy weapon’ disruptions; and, second, the states that have been hitherto net importers of energy may find themselves relatively better off vis-à-vis current net exporters. For example, current importers may find themselves with greater political leeway, whereas exporters will be grappling with a loss of revenue as well as leverage.

In sum, neorealists would view energy access as an integral component of military strength; neoliberal institutionalists would additionally recognize control over energy access as a way to potentially influence other countries. Both schools of thought, however, would agree that self-sufficiency protects against coercion and national weakness. In terms of renewable energies, states that attain self-sufficiency and, moreover, are able to become exporters, could be the geopolitical winners.

In the next section, the conditions that could lead to a country becoming a winner (or loser) will be explored. From the discussion thus far, one can surmise that winners would be the countries that transition from hydrocarbon sources of energy to renewables and have sufficient indigenous generation to supply their own electricity needs and potentially export excess to other countries. Whether and how quickly such a transition occurs depends on the strength of the facilitating and impeding factors in a country.

3.3 The Variables for or Against Renewable Energies

To assess whether a country will follow a predominantly hydrocarbon path or transition to renewable energies and greater deployment of electricity, one must first understand how technological transitions occur and how innovations are diffused and accepted. Here the insights generated by Frank Geels and other scholars who have developed the multi-level perspective (MLP) model for illuminating technological innovation and diffusion prove invaluable (see Geels 2002; Verbong and Geels 2007).

In brief, the MLP framework conceptualizes technological change as the result of push-pull forces occurring in three main spheres or levels. Some exogenous ‘landscape’ pressures facilitate technological change, such as major weather events, demographic changes, and global warming. Niche-level developments can also create momentum for change and include laboratory discoveries, civil society movements, and technological champions (think of Arnold Schwarzenegger and his hydrogen car). Between the landscape and niche levels lies the ‘socio-technical regimes’ level, which captures ‘how things are done now’ and includes soft factors (e.g. rules, norms, culture, and habits) and hard factors (e.g. extant infrastructure, factories and tools). Societal and political receptiveness play a role in facilitating technological diffusion, as do path dependencies and lock-in effects, which serve to perpetuate ‘how things are done now’ (Smith Stegen 2015b). Incumbent actors and firms who benefit from current practices are typically risk averse and resistant to change (see Campbell 2010). Indeed, they may actively attempt to quash technologies they perceive as competitors.

With the MLP framework as inspiration, variables have been selected for this study that represent, as closely as possible, the facilitating-impeding forces in a country. The factors favoring renewable energies are (1) a country’s raw renewable energy potential, and (2) the number of political measures to support a build out of renewable energies, such as feed-in tariffs. The impeding factor is the strength of the hydrocarbon lobby, or, if viewed as a factor facilitating a transition to renewables, the weakness of the hydrocarbon lobby. The hypothesis is that geopolitical winners will be those states with high potential for generating renewable energy combined with a high degree of socio-political support and a weak or non-existent hydrocarbon lobby.

Other factors might also potentially serve as proxies for push-pull forces, such as public opinion data towards climate change. However, as this study seeks to make a preliminary assessment of the *global* winners and losers, data covering the highest possible number of countries was prioritized. Thus, public opinion and other types of limited data were not used. Across all indicators, data was only considered for countries that are officially members of the United Nations (193 as of 2015).

3.4 Methodology and Results

3.4.1 Raw Renewable Energy Potential Variable (R)

Data was collected on the potential of wind energy (onshore and offshore), photovoltaic (PV), and concentrating solar-thermal power (CSP) for 165 countries. These three technologies were selected for two reasons: first, it is not possible at this point in time to acquire publically available estimations of *all* renewable energy sources. Several organizations are conducting such studies, but they are not yet completed (source: personal communications with representatives of the US Department of Energy’s National Renewable Energy Laboratory (NREL) and with Ecofys Consultancy). However, using geographic information system (GIS) technology, it is possible to make estimations of PV, CSP and wind (onshore and offshore) potential. Simply put: these three technologies are examined because they are the only three for which global data is readily available. Fortunately, these three (PV, CSP and wind) will comprise a significant portion of future energy use and thus can indicate how self-sufficient or dependent a country might be in a renewable energy world. According to estimations of future energy use by the German Advisory Council on Global Change (WBGU), these technologies could supply approximately 35% of global energy use by 2050 and almost 70% by 2100 (WBGU 2003).

The raw onshore and offshore wind and CSP data was derived from the Open Energy Information (OpenEI 2017) website, courtesy of the NREL. For the PV data, revised figures were acquired from the NREL (which the NREL will presumably also make available on the OpenEI site). In their raw forms, these three datasets provide a wide range of values. Because the goal of this study is to generate comparisons of the countries, relative to each other, the rankings of the countries has been used rather than the raw values (similar to assessing students from different schools according to their class rank as opposed to their GPAs). Using R software, the countries were ranked into ten categories, from the lowest 10% to the highest 10%. The countries were then given scores according to their decile, with 1 point for the lowest decile and 10 points for highest decile. For example, the 10% of countries with the least wind potential received 1 point. Conversely, the 10% of countries with the greatest wind potential received 10 points; and the second 10% of countries with the next greatest amount of wind potential received 9 points, and so on.

For onshore and offshore wind energy potential (as measured by gigawatt-hours, GWh), placing the countries in minimum-to-maximum deciles produced the following distribution of values:

1 point: 0.2415–63.4710
2 points: 63.4711–142.0805
3 points: 142.0806–230.3530
4 points: 230.3531–396.3139
5 points: 396.3140–679.0773
6 points: 679.0774–953.4276
7 points: 953.4277–1,979.6008
8 points: 1,979.6009–2,748.3620
9 points: 2,748.621–5,478.0810
10 points: 5,478.0811–39,1667.3273

The same process was repeated for the two solar measures, generating the following distributions:

(1) CSP potential, as measured by terawatt-hours (TWh):

    1 point: 0–838
    2 points: 839–1,770.5
    3 points: 1,770.6–3,321
    4 points: 3,332-7,079.5
    5 points: 7,079.6–11,481
    6 points: 11,482–18,008.5
    7 points: 18,008.6–36,877
    8 points: 36,878–56,687.5
    9 points: 56,687.6–109,421

10 points: 109,422–778,611

(2) PV potential, as measured by megawatt-hours (MWh) per year:

1 point: 793.7323–31,608,742.3047
2 points: 31,608,742.3047–72,350,892.5253
3 points: 72,350,892.5254–138,119,861.2166
4 points: 138,119,861.2167–319,043,979.9127
5 points: 319,043,979.9128–480,236,703.5433
6 points: 480,236,703.5434–736,559,441.5525
7 points: 736,559,441.5526–1,354,153,408.3596
8 points: 1,354,153,408.3597–2,685,292,035.9071
9 points: 2,685,292,035.9071–4,967,990,841.6423
10 points: 4,967,990,841.6424–30,586,340,906.7045

3.4.2 Political Receptiveness Indicator (P)

The raw potential for renewable energies does not indicate, however, whether a country's denizens and policy makers have the socio-political will to develop or capitalize this potential. Thus, a variable was created to capture socio-political receptiveness to renewable energies. Numerous proxies were considered, including several opinion variables from the World Values Survey (WVS). Unfortunately, however, no WVS variables directly measured receptiveness and the closest proxies were only available for 50-odd countries. Under the logic that politicians are (somewhat) following public wishes—particularly in democracies—a variable was developed that reflects political receptiveness. This political receptiveness indicator is based on the Renewable Energy Support Policies data, provided in the Renewables 2016 Global Status Report (GSR) published by the Renewable Energy Policy Network for the 21st Century (REN21 2016). The REN21 GSR data reports on the renewable energy policies of 194 countries, for example, does a government offer feed-in tariffs, quota systems or other policy instruments to encourage renewable energies? The assumption is that a higher number of policies indicates a higher level of political receptiveness. The dataset contains information on 16 possible policy measures and the average is 7.41 per country.

After splitting the dataset into deciles with the help of R software, points were assigned from 1 (lowest) to 10 (highest). A large number of countries had 3–4 or 8–9 or 10–11 or 12 and more measures, so these were grouped together.

1 point: 0 measures
2 points: 1 measure
3 points: 2 measures
4 points: 3–4 measures
5 points: 5 measures
6 points: 6 measures
7 points: 7 measures
8 points: 8–9 measures
9 points: 10–11 measures
10 points: 12+ measures

3.4.3 Hydrocarbon Lobby Indicator (H)

Even if a country has significant potential for renewable energy generation and a fair number of policy measures in place to coax a transition, the country might still lag behind other countries in actually developing its potential. As the MLP Framework reminds us, incumbent firms and other actors might view renewables as competing technologies and resist or even obstruct a large-scale switch to renewable energies. As fossil fuels have been the predominant energy sources for many decades and are the energy sources that renewable energies will supplant, hydrocarbon industries and firms are and will continue to be the main opponents of a country's transition to renewable energies. An assumption of this study is that hydrocarbon reserves could be an appropriate indicator of opposition to renewable energies as countries with significant reserves are more likely to have incumbent hydrocarbon-path dependent industries and firms. A composite variable 'Hydrocarbon Lobby' comprising a country's oil, natural gas and coal reserves was thus created. The data for this variable was sourced from the 2016 CIA World Factbook and from the Energy Information Agency (EIA 2017)'s Beta *International Energy Statistics*.[3]

The same method was used to assign points to each country for each of the three measures. As the hypothesis is that the weaker the lobby, the greater the potential for a build out of renewable energies, the countries with the highest amount of

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[3] An alternative variable could have been the number of oil, gas and coal companies in a country, but this data is not readily available for all countries in this study.

hydrocarbon reserves were given the lowest score (1) and countries with zero or marginal hydrocarbon resources were allotted the highest number of points (10).

Oil Reserves (as measured by barrels divided by 100,000,000):

1 point: 120–3,000
2 points: 23.5–119.9
3 points: 4–23.4
4 points: 1–3.9
5 points: 0.1395–0.999
6 points: 0.001–0.1394
10 points: <0.001

Note: Hydrocarbon resource endowments are extremely skewed, with some countries possessing massive quantities of hydrocarbons and others, about 40% of all countries, holding negligible amounts. Each country in this 40% was given 10 points; hence the jump from 6 points to 10.

Natural Gas Reserves (as measured by cubic meters divided by 1 000 000 000):

1 point: 1,996–47,800
2 points: 423.5–1,995
3 points: 134.7–423.4
4 points: 26.62–134.6
5 points: 5.663–26.61
6 points: 0.024776–5.662
7 points: 0.0001–0.024775
10 points: <0.0001

Note: similar to oil reserves, about 30% of countries have 0 m^3 of natural gas, meaning that each country in this category was allotted 10 points.

Finally, 50% or more of the countries in the dataset had 0 coal reserves, and were assigned 10 points each.

Coal Reserves (as measured by metric tons):

1. point: 179.623–731.191
2. points: 34.8721814–178.715
3. points: 3.71038559–34.86311
4. points: 1.184329678–3.7094784
5. points: 0.0001–1.184329678

To calculate the 'winners' and 'losers'—or laggards—the various inputs and datasets were combined. In order to assign numerical values and integrate all datasets into one final ranking of all countries, a 1–10 point system was devised and the points summed for each country and then divided by the number of sub-indicators for each variable. The three variables were then integrated into one formula:

$$\frac{\mathrm{R}+\mathrm{P}+\mathrm{H}}{3} = \text{Winner Potential}$$

R Raw Potential Variable
P Political Receptiveness Indicator
H Hydrocarbon Lobby Variable

The weighting of these variables plays a significant role in determining whether a country might be a winner or near winner (or laggard or near laggard). As this is a preliminary study, other analysts are invited to participate in a discussion regarding the optimal approach. To help launch such a discussion, two different results tables are provided. Table 3.1 indicates the results if each variable is considered equally. However, this might understate the power of incumbent fossil fuel industries to disrupt a transition; thus, in Table 3.2, H is counted twice.

This analysis is preliminary and the results are merely suggestive. They should not be construed as definitive in any shape or form. However, it is interesting that some of these results overlap with the outcomes of other studies seeking to ascertain which countries might lead in the transition to renewable energies. The Climate Reality Project (2016), for example, lists eleven countries. Those shown in bold also appear in this chapter's study: **Sweden**, Costa Rica, **Nicaragua**, Scotland, Germany, **Uruguay**, Denmark, **China**, **Morocco**, the **US** and **Kenya**. Most likely these states would be self-sufficient. Could these beneficiaries of a transition to renewable energy also be the geopolitical heavyweights of the future?

From today's perspective, it is difficult to imagine that some of the smaller and weaker states that appear as winners in the results tables could play a new role on the world stage. However, Denmark, for example, was once a geopolitical powerhouse. And, a little over a century ago, the sun never set on the British Empire. The historical lesson is that the fortunes of countries rise and fall in unexpected ways. In the past, the social, political and economic changes ensuing from a wide-scale transition from one energy source to another—for example, from coal to oil/natural gas—produced unexpected power dynamics and geopolitical reconfigurations. One could expect that the same will occur with the transition from hydrocarbons to renewables. As with past transitions, the states at the forefront of the transition will gain numerous first-mover advantages.

In terms of laggards, one country notably absent from the list of winners is Russia, which in recent years has sought to regain its status as a major world power. If Russia continues to neglect renewable energies, then the renewable energy era may be one in which Russia's national power and stature decline. A similar scenario could hold true for the US, if the incentive structure is changed so that fossil fuels become more attractive than renewables—which seems to be the direction favored by US President Trump.

In sum, the factors that could facilitate or impede a transition to renewable energies have been operationalized to preliminarily indicate which countries could be the geopolitical 'winners' or 'losers' in a renewable energy world. Based on the insights of IR theory, the more powerful states are those that have more and not less

Table 3.1 Geopolitical winners and laggards with (R + P + H)/3

World region	'Winners'	Points	'Laggards'	Points
Sub-Saharan Africa	Namibia	8,7	Gabon	4
	Kenya	8,6	Swaziland	4,4
	Mali	8,3	Burundi	4,6
Middle East and North Africa (MENA)	Jordan	7,3	Qatar	2,5
	Algeria	6,8	Bahrain	3
	Morocco	6,7	Kuwait	3,1
East Asia and Pacific	Mongolia	7,1	Brunei	2,4
	China	7	Timor-Leste	3,4
	Australia	6,7	Samoa	4
Europe and Central Asia	Sweden	8	Slovakia	3,6
	Finland	7,9	Georgia	3,7
	France	7,4	Czech Republic	4,3
South America and the Caribbean	Uruguay	8,8	Trinidad and Tobago	3,4
	Nicaragua	7,4	Belize	3,7
	Honduras	7,3	Puerto Rico	4
North America	USA	7	N/A	N/A
	Canada	6,7	N/A	N/A
	N/A	N/A	N/A	N/A
South Asia	India	7,3	Bhutan	3,6
	Sri Lanka	7,1	Bangladesh	4
	Pakistan	6,3	Afghanistan	5

energy. Energy, after all, is a key component of military might. Moreover, if a state has abundant energy, it could become an exporter and apply pressure on its more dependent partners. At the moment, it is not possible to discern which countries will become exporters, but the countries in this study's 'winner' category are likely to have that potential.

Thus far the discussion has focused on electricity generation and export. The next section examines more closely how electricity could be manipulated (or not) and introduces two other types of export dependencies that could become problematic in a renewable energy world.

3.5 Renewable Energy and Dependencies

If states in a renewable energy world do enter energy-related relations, these would most likely be in the form of interconnected grid systems, which states may seek in order to reap efficiency gains. A prime example is the Nordic electricity exchange, Nord Pool Spot, which connects parts of Denmark, Finland, Sweden, Norway,

Table 3.2 Geopolitical winners and laggards with (R + P + 2H)/3

World Region	'Winners'	Points	'Laggards'	Points
Sub-Saharan Africa	Kenya	12	Gabon	5,9
	Mali	11,7	Cameroon	6,6
	Namibia	11,3	Swaziland	6,8
Middle East and North Africa (MENA)	Jordan	9,6	Qatar	2,5
	Malta	9,3	Kuwait	3,8
	Lebanon	8,4	Bahrain	4,6
East Asia and Pacific	Mongolia	9,8	Brunei	4,2
	Cambodia	9,1	Myanmar	5,4
	Fiji	8,7	Timor-Leste	6
Europe and Central Asia	Finland	11,3	Georgia	4,9
	Sweden	10,8	Slovakia	5,1
	Belgium	10	Romania	5,5
South America and the Caribbean	Uruguay	12,1	Venezuela	4,4
	Nicaragua	10,8	Trinidad and Tobago	5,2
	Honduras	10,6	Bolivia	5,8
North America	Canada	7,4	N/A	N/A
	USA	7,3	N/A	N/A
	N/A	N/A	N/A	N/A
South Asia	Sri Lanka	10,2	Bangladesh	5
	Nepal	8,6	Bhutan	6,1
	Maldives	8,5	Afghanistan	7

Estonia and Lithuania. A key difference between these types of dependencies and hydrocarbon-era dependencies is that interconnected grid systems have a built-in 'safety' mechanism that inhibits any state—or other actor—connected to the system from interfering with the system (Smith Stegen et al. 2012). Such trade relations are symmetrical, because the dependence is mutual. Thus, in a renewable energy world, we could expect greater self-sufficiency and/or mutual dependence, in which the partners would be unable to threaten or disrupt each other's supply. However, there are at least three areas in which asymmetrical dependencies may arise: reliance on imports of (1) electricity via high-voltage direct current (HVDC) lines; (2) biofuels; and (3) critical materials. These three have been selected because they comprise, at the moment, the most apparent potential dependencies associated with renewable energies.

3.5.1 HVDC Transmission Lines

Areas that have insufficient local supplies and are not connected to regional grids might have to import electricity from elsewhere. These “make” or “buy” decision might also be driven by economic factors: even if a state could generate electricity, it might opt for imports for cost reasons (Scholten and Bosman 2016). Countries that import electricity will be dependent on their suppliers, which could be states as far away as 3000 km, the maximum length for a HVDC line before efficiency losses render it uneconomical.

Usually electricity supply cannot be easily interrupted because most transmission occurs within interconnected grid systems. But HVDC export lines that are not connected to the supplier’s system could indeed be manipulated, particularly if they were designed so that electricity flows could be controlled (personal communications with an industrial engineer specializing in transmission infrastructure, 2011).

Cross-border transmission lines could be manipulated by at least two actors: the supplier state and/or transit states. First, the supplier state could interrupt electricity to exert pressure on its customer(s), similar to how Russia has reduced or halted pipeline gas to influence the domestic or international behavior of its customers. For a state to deploy an ‘electricity weapon’, the same three conditions must be fulfilled as for oil or natural gas supply: the exporting state must (1) control the supply; (2) control the transport; and (3) use these controls to exert political pressure (Smith Stegen 2011). If an electricity-producing state fulfills all three conditions, then it could disrupt supply.

Second, transit states could also manipulate supplies to pressure either the exporting state or the importing state (Smith Stegen and Brandstätt 2011). If long-distance HVDC lines are deployed, they could cross one or more intermediary states. For example, the DESERTEC concept envisioned that concentrating solar-thermal power (CSP) generated in the world’s deserts could supply 90% of global energy demand (DESERTEC.org), which would entail HVDC lines crossing multiple transit states. Figure 3.1 is based on a map used by DESERTEC to indicate the most suitable locations for CSP generation—the world’s deserts—and the areas of high electricity consumption. The arrows and numbers have been added to indicate the HVDC lines that could supply electricity from the deserts—the darkened areas—to demand centers and the number of international borders each line would cross. As depicted in Fig. 3.1, most of the lines transporting CSP-generated electricity would cross two to three transit states. This scenario of multiple transit countries is not limited to the DESERTEC concept; it could also occur for geothermal, wind or any other renewable sources of electricity that could be exported long distances.

At the moment, there are only a few examples of ‘energy weapon’ disruptions of electricity supply. During the 2006 conflict between Russia and Georgia, electricity lines into Georgia were destroyed (BBC 2006). In 2015, Ukraine severed the power lines to Russia-occupied Crimea (Paltsev 2016), but this was implemented as a permanent punitive measure, rather than in hopes of attaining foreign policy concessions.

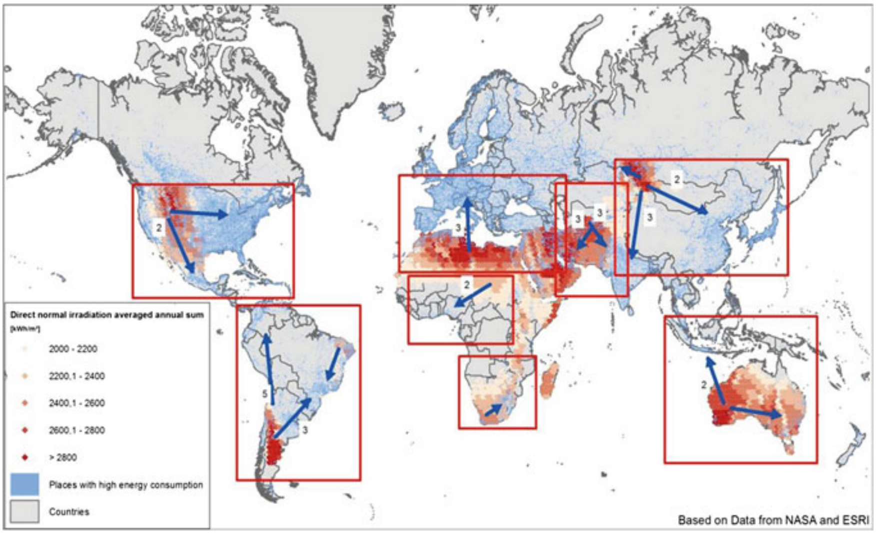

Fig. 3.1 Deserts and electricity demand centers, with HVDC lines and number of transit countries. *Source* Bremer Energie Institut/Author's files

In addition to actual disruptions, concerns have been expressed over the potential for manipulation. In 2011–2012, for example, Finland experienced episodes in which, with very short notice, it received less electricity from its HVDC link with Russia. It seems Russia had changed its domestic tariff rates and the Russian power plant feeding the HVDC line to Finland was diverting electricity to demand centers in Russia from which it could earn greater revenues (Staalesen 2013). Although Russia was not reducing supply to Finland for political gain, experts within Finland realized that the Russia-Finland HVDC link fulfilled the energy weapon conditions and were concerned by the implications (personal communications 2012).

There are at least two ways in which importers of foreign-sourced electricity could mitigate the risks of manipulation. First, they could negotiate that the HVDC lines are designed to be constantly 'on'. This would mitigate against manipulation, but would not, of course, mitigate against the destruction of the line. Second, the importer could negotiate that its electricity supply is connected to the exporter's grid, if technically feasible.

3.5.2 Biofuel Feedstocks

A second way renewable energy supply could be manipulated is by disruption to the delivery of biofuel feedstocks. So long as the three 'energy weapon' conditions obtain, biofuels that are imported are vulnerable to the same supply risks as imported hydrocarbons: exporters that control production and delivery could cut or reduce supply. Importers of biofuels, however, cannot rely on the same protective mechanisms that oil suppliers have in place. After the 1970s oil crises, oil consumers banded together and formed the International Energy Agency, which protects consumers from disruptions through various measures, including exchange agreements between consumers and requirements that each member keep a 90-day strategic supply of oil. No such protections exist at the moment for importers of biofuels (but such an arrangement could plausibly be instituted).

Although the next point does not pertain to geopolitical power, it should be noted that biofuels are not renewable in the same way as solar or wind energy. Biofuels are agricultural products and are thus vulnerable to disruptions the same as any other crops, for example, they require access to water, land, fertilizers and pesticides, and are dependent on weather conditions. Second-generation biofuels are byproducts of first-generation crops and are only produced if sufficient demand obtains for the primary crop. Last but not least, biofuels produce emissions. Biofuels are only considered renewable because they can be grown and are only deemed ‘sustainable’ because the growth process consumes carbon. They are, at best, ‘carbon neutral’. Under a scenario in which global warming drastically increases and carbon emissions must be radically curtailed, biofuels may lose their allure.

3.5.3 Critical Materials

The first two areas of vulnerability to geopolitical manipulation were actual sources of renewable energy, electricity (via HVDC lines) and biofuels, which, if imported, would create dependent supply relationships. In addition, the technologies for producing many forms of renewable energy—such as solar cells and wind turbines—are themselves dependent on materials, several of which are considered ‘critical’. Government agencies and others have expressed concerns that these materials could pose supply risks, in part because they are mined and produced in relatively few countries (EU Commission 2010). Energy analysts have also warned about the risks of relying on a dominant supplier of critical materials (Smith Stegen 2015a) and about the potential for manipulation (Criekemans 2011; Klare 2012). The disruption of supplies would not affect already installed technologies, but could dampen further build out of renewable energy capacity. Disruptions would also have a deleterious effect on countries that manufacture and export renewable energy technologies.

With regard to renewable energy generation, five materials are of particular importance: gallium, tellurium, indium, neodymium and dysprosium (Rabe et al. 2017).[4] The latter two are components of the permanent magnets used in gearless direct drive wind turbines (Lacal-Arántegui 2015). Critical materials also appear in

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[4] Supply security concerns have also been raised about lithium. It is not covered in this chapter because lithium is used in batteries (for example, for electric vehicles), whereas this chapter focuses on electricity generation.

Table 3.3 World estimated mined production of critical materials (SETIS material information systems)

Raw material (Data Year)	# of Producers	Top World Producers	% of World Production
Gallium (2012)	8	China	70
		Germany	10
		Kazakhstan	6
Tellurium (2011)	12*	China	18
		Japan	14
		Belgium	13
Indium (2013)	7*	China	53
		Korea	19
		Japan	9
Neodymium (2012)	5	China	91
		US	4
		Australia	3
Dysprosium (2012)	4	China	99
		Australia	1

Note The asterisks indicate that, beyond the main producers, a small amount of the material was also produced by other countries. It should be noted that the US's production of neodymium ceased in 2015 when the country's sole mine closed

solar PV technologies. As their name suggests, copper indium gallium selenid solar cells (CIGS-cells) require gallium and indium (Schriefl and Bruckner 2016). Cadmium tellurid cells (CdTe-cells), which comprise around 70% of the market for thin film solar cells, require tellurium, gallium and indium. As Table 3.3 indicates, the primary supplier for all five materials is China.

In sum, there are at least three areas in which dependencies in a renewable energy world could become an issue: (1) HVDC transmission lines, (2) biofuels, and (3) critical materials. In Sects. 3.4 and 3.5 the forces facilitating and impeding a transition to renewable energies were presented and operationalized. It is likely that the “winners” could run HVDC lines to other countries. However, it is not possible to calculate, at the moment, which countries might be dependent on HDVC lines, biofuels or critical materials. An argument could be made that the “winners” might not need imported biofuels (presumably because they are using electricity for electric vehicles, etc.). In terms of critical materials, all countries but China could be dependent on imports.

3.6 Conclusion

This chapter began by exploring what it might mean to be a geopolitical winner in a renewable energy world—a world in which electricity generated by renewable energies has mostly supplanted reliance on oil and natural gas. As the discussion of neorealism and neoliberal institutionalism indicated, similar to the hydrocarbon world, energy-related dependencies will continue to render states vulnerable to external pressure. Fortunately, in a renewable energy world, many states will be able to supply a far greater share of their own energy needs. The exceptions will be states that must import electricity, biofuels or critical materials. For the most part, however, the heavy reliance on foreign sources of supply, one of the hallmarks of the hydrocarbon era, will lessen. Current net importers of energy are likely to see their dependencies decrease. Although some of the potentially negative geopolitical aspects of renewable energies have been emphasized in this chapter, the effect of renewables on international relations should be net positive—particularly in comparison to the political and strategic dilemmas wrought by dependence on hydrocarbons.

If the increasing use of renewable energy sources encourages more networked energy relations, we may expect new forms of interstate relations to emerge and deeper regional integration to ensue. European integration, for example, has been furthered by energy networks between the Member States (Johnson and Turner 1997). Moreover, Haas (1990) brought forward the notion of 'epistemic communities', in which networks of actors (both state and non-state) share their political, economic, and social resources as well as collect information, disseminate knowledge, and form common values. The notion of 'transnational advocacy coalitions' (Keck and Sikkink 1998) is similar in many respects. These concepts share a positive vision of state relations.

Thus, this chapter issues a warning as well as offers an optimistic vision of the future. States that cling to fossil fuels may suffer significant consequences and are more likely to become entangled in energy-related conflicts. The states and regions that opt for renewables, however, will have (at least) two political advantages: (1) they will be less likely to spar with each other over energy and, (2) the interconnectedness required of renewable energy communities may bring us closer to a 'functionalist' (Haas 1958; Mitrany 1966) model of collaboration, in which economic and technical collaboration can potentially lead—via spill-over effects—to political cooperation and stability.

An additional contribution of this chapter was the introduction of a new model for understanding the transition from fossil fuels to renewable energies. The hypothesis underlying this model is that states are more likely to transition if they have (1) high levels of raw renewable energy potential, (2) socio-political support for a transition, and (3) a weak hydrocarbon lobby that would seek to obstruct a transition. The results are preliminary but intriguing as several small countries appear as winners whereas some current powers—such as Russia—are absent from the list of winners. It could be that other results would obtain if other variables were used or if the weighting of the variables was modified. The author thus invites a discussion of how the global transition from fossil fuels to renewables can best be portrayed.

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Chapter 4
Battling for a Shrinking Market: Oil Producers, the Renewables Revolution, and the Risk of Stranded Assets

Thijs Van de Graaf

4.1 Introduction

A full appreciation of the geopolitics of renewables necessitates a close look at not just the winners but also the losers of the energy transition. The incumbent fossil fuel industries are often portrayed as potential losers, and thus key obstacles, to such a renewable transition. The oil, natural gas and coal industries are no doubt large-scale, politically powerful and well-entrenched industries. Fossil fuels still provide no less than 80% of worldwide energy. They exhibit a high degree of 'lock-in' (Unruh 2000) with the transportation sector being almost completely reliant (93%) on petroleum products, whereas coal is the leading energy source for electricity generation worldwide (with a market share of around 40%). Coal-fired power plants entail large up-front investments and have long operating lifetimes (typically 30–50 years). The same goes for large-distance oil and gas pipelines, liquefied natural gas (LNG) tankers and terminals, or offshore oil rigs.

It should come as no surprise, then, that the fossil fuel industries have put up stiff resistance to a large-scale transition to renewables. The coal industry has touted the idea of 'clean coal' and the innovation promise of carbon capture and storage (CCS). Major oil companies have notoriously sponsored climate-denial campaigns (Oreskes and Conway 2011), and they have continued to invest in the development of new reserves, including risky ones such as tar sands, deep-water fields and shale reserves. The natural gas industry has attempted to position itself as the provider of an important 'bridge fuel' in the low-carbon transition. Likewise, the nuclear industry has floated the 'nuclear renaissance' discourse, although it has arguably taken a blow after the Fukushima nuclear accident (Geels 2014).

The goal of this chapter is to examine how a particular set of actors within the oil industry is coping with the rapid spread of renewable technologies in the global

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energy market. The impact on the operations of the private international oil companies is briefly discussed, but much more attention is given to the oil-exporting states and their national oil companies. After all, 90% of oil reserves are in state hands. If these are left in the ground because of a global transition to renewables, many oil exporting countries will suffer economic losses. As we will see, not all oil producers will be affected equally by a surge in renewables. The future looks bleak for countries such as Saudi Arabia and Russia that are heavily dependent on oil revenues and have few competitive industries beyond fossil fuels. Others with a broader economic base, like Iran, may fare better. Ultimately, their fate hinges on which strategy they choose: short-term adaptation or long-term transformation.

4.2 Analytical Approach and Structure

Energy has long been overlooked in the fields of international relations, political science and international political economy (Van de Graaf et al. 2016). Only oil has received some attention, but it has been approached almost exclusively from hard-nosed, geopolitical perspectives. Furthermore, studies of the geopolitics of oil (or gas for that matter) have generally been disconnected from broader issues of decarbonization and climate change policies. This is related to the fact that the extant literature on global oil politics is preoccupied with security of supply issues, and tends to overlook the demand side.

This chapter hopes to help fill this gap. While doing so, it speaks to two different strands in the literature on the political economy of energy. First, it draws on the literature on the nature and types of technological innovation. This chapter argues that the rise of renewables and related technologies (e.g. batteries and the electrification of transport) represents a ‘disruptive’ challenge to the oil industry. A particularly useful perspective in this regard is the so-called ‘S-curve’ of innovation, according to which a particular technological innovation first grows slowly but then reaches a tipping point, after which it is adopted on a massive scale (Christensen 2013). Second, it relates to the literature on the resource curse and rentier states. The resource curse thesis, sometimes also referred to as the ‘paradox of plenty’ (Karl 1997), holds that abundance of natural resources is correlated with poor economic performance (Sachs and Warner 1995), low levels of democracy (Ross 2001), and civil war (Collier and Hoeffler 2004). The prospect of peak oil demand turns the ‘resource curse’ hypothesis on its head since it is the loss of resource rents, rather than their abundance, that will warp the domestic political economy of oil-exporting countries if oil is increasingly displaced by renewables.

This chapter proceeds in the following manner. The next section reviews the advantages of oil, which propelled it to the most important energy source in the global economy. Section 4.4 discusses the likelihood of peak oil demand. Section 4.5 looks at how private international oil companies are affected by these disruptive shifts in technology, and how they have responded. Section 4.6 examines how OPEC producers would be affected by a global transition to renewable energy, and looks specifically at how it affects their power. Section 4.7 considers possible strategies that OPEC countries might decide to follow in the face of dwindling demand. The subsequent section homes in on the geopolitical consequences of a global shift away from oil. A final section concludes and discusses the results.

4.3 The Indispensable Fuel and the Making of the Modern World

It is hard to overstate the economic and political importance of oil. Throughout the twentieth century, oil has been the material basis of global economic life (DiMuzio 2012). Oil is the single largest source of the world's energy supply, accounting for one-third of global energy consumption (BP 2017). More than 90% of the energy used in transportation still comes from oil-based fuels, a proportion that has changed little since the oil shocks of the 1970s (IEA 2013, 510). Thanks to the geographical concentration of oil reserves, oil has also shaped patterns of conflict and cooperation in international politics (Colgan 2013). It has warped the domestic politics of oil-exporting states in ways that are not always benign (Ross 2012), and it has even affected democracy in the leading industrialized countries (Mitchell 2011).

Ever since the first modern oil well was drilled in Pennsylvania more than 150 years ago, the oil sector has expanded significantly. Over the last century, and especially after World War II, oil demand has grown in step with economic output. Since 1965, oil consumption has risen from about 30 million barrels a day to more than 90 million barrels a day in 2015 (BP 2017). Conventional wisdom holds that the oil market will continue to expand for at least the next 25 years. The International Energy Agency's (IEA) central scenario, for instance, sees oil demand rising from 92.5 million barrels per day in 2015 to 103.5 million barrels per day in 2040 (IEA 2016, 111). The energy outlooks of international oil companies all project similar, or even stronger demand growth (Van de Graaf and Verbruggen 2015). ExxonMobil (2015), for instance, sees global liquids output rise to 112 million barrels per day over the same period.

On the face of it, there seem to be good reasons to believe that oil will continue to play the pivotal role in powering the world economy as it has done over the past decades. First, new discoveries and technological advances have largely dispelled fears of peak oil. Such fears were especially widespread around 2008, when oil prices rallied to a record level of almost 150 dollars a barrel. While the Great Recession drove oil prices down, they recovered quite quickly and hovered above 100 dollars a barrel from 2011 to mid-2014. Many analysts believed that oil prices were there to stay (Hamilton 2014). However, advances in unconventional production of oil—most notably shale oil, ultra-deepwater, and oil sands—have completely upended that view. These advances have demonstrated that the oil market is, in fact, not characterized by scarcity but rather by abundance. Costs have come down across the entire upstream sector in recent years, which goes a long way to explaining why the shale oil industry has been so resilient to the price fall after 2014 (IEA 2017).

Second, oil has unique physical properties that make it highly attractive as an energy source and as a feedstock. Its high energy density—nearly twice as much as coal by weight, and around 50% more than liquefied natural gas (LNG) by volume—and liquid properties make oil is easy to transport and to store. Unlike natural gas or coal, oil can be moved over distance with comparatively few energy and labor inputs. The chemical properties of oil make it valuable as a feedstock for the manufacturing of new materials, including plastics, synthetic fibers, and a range of chemicals (Bridge and Le Billon 2013). There are readily available economic alternatives to the use of oil in power generation, buildings and industrial boilers, but less so for the use of oil as a fuel in transportation—especially for trucks and plains—and as a feedstock petrochemicals (IEA 2016, 116–117). At present, most renewable energy is distributed generation such as solar or wind, which are geared toward the electricity sector and which, by themselves, are unable to challenge the dominance of the internal combustion engine, for instance, or provide an alternative feedstock for the use of oil in the chemical sector.

Third, even though the threat from climate change has created acute incentives to decarbonize the economy, policy-makers have failed to act on it. While almost 200 nations have agreed to limit global warming to "well below 2 °C" in the Paris Agreement of late 2015, current pledges will still see temperatures rise by 3.4 °C above pre-industrial levels (UNEP 2016). The decision by the Trump administration to withdraw the United States from the Paris Agreement only adds more doubt about whether the pledges will actually be met. Moreover, not all fossil fuels will be equally impacted if carbon mitigation policies are put into effect. Coal is the dirtiest of all fossil fuels, not just in terms of carbon emissions released after combustion but also in terms of air pollution. Putting a price on carbon, whether through a cap-and-trade system or through a tax, would thus hit the coal sector far worse than it would hit the conventional (or 'easy') oil sector. This explains why so many oil companies are actually in favor of a carbon price. McGlade and Ekins (2015) estimate that around a third of oil reserves are "unburnable" in a 2 °C world, compared to half of natural gas reserves and up to 80% of coal reserves. Ironically, fossil fuels are still heavily subsidized on a global scale, even to a larger extent than renewables (Van de Graaf and van Asselt 2017).

4.4 Assessing the Likelihood of Peak Oil Demand

In spite of oil's abundance, low cost, high energy density, and liquid properties, there is a case to be made that oil demand will peak and decline in the near future. The global economy is getting more efficient, with less oil burned per unit of gross domestic product (GDP). Figure 4.1 shows the declining oil intensity of global economic growth. What is more, oil demand in the industrialized countries of the

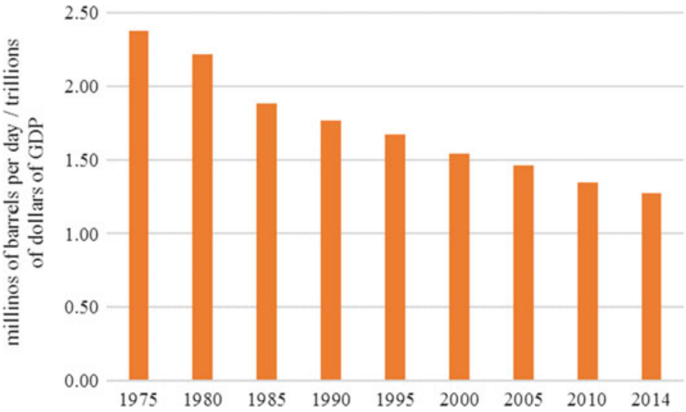

Fig. 4.1 The declining oil intensity of global economic growth, 1975–2014. *Sources* Oil consumption data from BP (2017), GDP in constant $2010 from World Bank (2017)

Organization for Economic Cooperation and Development (OECD) has already declined *in absolute terms* from over 50 million barrels per day in 2005 to 45.6 million barrels per day in 2015 (BP 2017). Oil demand has fallen in Japan since 2003, in the European Union since 2005, and in the United States since 2007. In other words, the fall in oil predated the Great Recession of 2008–2009. The industrialized countries now use the same amount of oil as they did in 1995–1996, even though their economies have grown much bigger over that period. The European Union is even back at consumption levels last seen in 1984 (BP 2017). Most projections confirm that oil demand in the OECD is not experiencing a cyclical downturn but rather a structural decline—meaning that oil demand is displaced by demand for other types of energy. The IEA's central scenario sees oil demand in the OECD dropping from 41.5 million barrels per day in 2015 to 29.8 million barrels per day in 2040 (IEA 2016, 111).

The key reason why the OECD's oil demand might never return to its 2005 peak is that the position of oil in its main market, transportation, is increasingly coming under strain. Oil use in industry, buildings, and power generation declined dramatically in the wake of the oil shocks of the 1970s, and have remained relatively flat since 1980. The transportation and petrochemical sectors have been the last vestiges where oil has remained dominant, and it is the growth in these end-use sectors that have fueled overall petroleum demand growth. Yet, a number of long-term trends are biting into the oil demand from the transportation sector: vehicle ownership rates have reached a 'saturation' level, fuel economy standards become ever tighter, and alternative fuels (e.g. biofuels or natural gas) and vehicle technologies (e.g. electric vehicles) are gaining market share (IHS CERA 2009).

In mainstream projections, the decline in the OECD's oil demand is expected be more than offset by an increase in oil demand from the non-OECD countries. In the IEA's central scenario, India will add 5 million barrels per day, China will add 4.1 million barrels, and the Middle East will add 3 million barrels per day to global oil demand by 2040 (IEA 2016, 115). There are at least three reasons to doubt whether these countries will need as much as oil as that.

First, projections such as these are very sensitive to growth assumptions. If these economies do not grow as rapidly as projected—for example, if the global economy remains mired in secular stagnation (Summers 2014), oil demand will turn out to be much lower.

Second, technological advances and market shifts might start to challenge the dominant position of oil. In the short term, the shale gas revolution, along with increased LNG export capacity in countries such as the US, Qatar and Australia has already helped to create a global gas glut, which has strengthened the position of natural gas as a tough competitor for oil. In the medium term, the dramatic fall in the costs of alternative energy technologies such as solar and batteries will likely be a game changer for oil markets (UNEP and BNEF 2016; Sussams and Leaton 2017). These two reasons—sluggish growth and the rise of renewables—are probably sufficient to flatten off and reverse oil demand growth in the 2020s, even before climate policy kicks in (Helm 2017, 83).

A third and final reason why the demand for oil might soon stop rising and then begin to fall back again, are the government policies to mitigate the financial and environmental costs of oil consumption. A prime example is the recent curtailing of oil subsidies in countries such as China, India and Indonesia, the main engines of oil demand growth in Asia over the coming years. Policies to combat air pollution could also favor a transition away from oil. India's energy minister Piyush Goyal has unveiled a plan in 2017 to make every car electric by 2030 (Agerholm 2017)—quite a bold move for a nation that is expected to be the world's fastest-growing oil consumer over the next two decades (IEA 2016). Ambitious deployment targets have been announced by key consumer countries (IEA 2016, 123), as well as major car manufacturers (including Volkswagen, Honda and Renault-Nissan), and electric vehicles (EVs) might displace as much as 16.4 million barrels of oil per day by 2040 (see Fig. 4.2). Moreover, it is not just national governments that are driving these changes: a number of cities have been at the forefront of experimenting with novel transport services based on vehicle and ride-sharing concepts or autonomous driving capabilities. The pursuit of alternative urban transportation models would allow countries like India to leapfrog the US car-centric model. Incrementally, these changes will dampen demand in a market that is already over-supplied, suggesting greater volatility and lower oil prices.

The ultimate reason why oil demand growth might not take place as projected is of course the urgent imperative to mitigate climate change. To keep average global warming "well below 2 °C" by the end of the century, as agreed in the Paris Agreement, oil demand *has* to peak by as early as 2020 according to the IEA's 450 Scenario (see Fig. 4.3). Even so, there are two reasons why oil may have to be curtailed even more sharply and rapidly than envisioned in the IEA's 450 scenario. First, the IEA's only corresponds to a 50% likelihood of staying below 2 °C, which is tantamount to playing Russian roulette with the fate of our planet. In recent years, as climate science has progressed, it has increasingly become clear that 2 °C should not be seen as a "safe" target, because severe impacts will begin to kick in much earlier (UNFCCC 2015). Second, even for that questionably safe target, the IEA

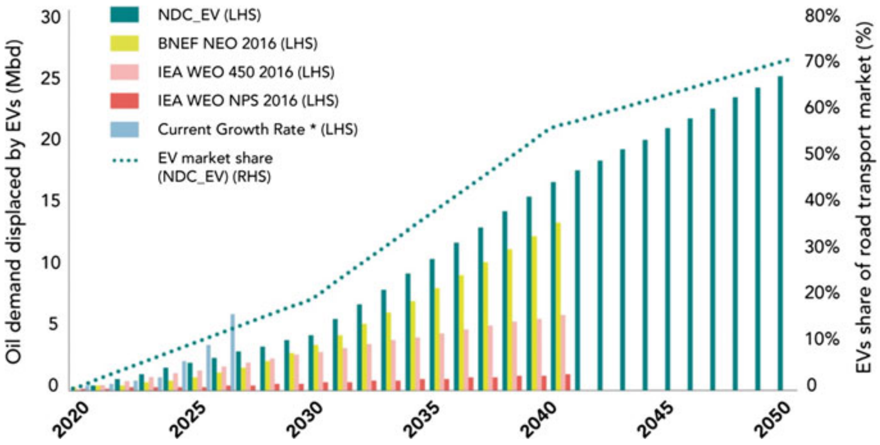

Fig. 4.2 Comparing levels of oil demand displaced by EVs across projections. *Notes* Asterisk Current growth rate is derived from Bloomberg data and assumes EV sales increase by 60% year on year. "NDC_EV" is the scenario assuming a level of climate policy action consistent with the nationally determined contributions of Paris, combined with lower EV costs. "BNEF" = Bloomberg New Energy Finance. "NEO" = New Energy Outlook. "WEO" = World Energy Outlook. "NPS" = New Policies Scenario. *Source* Sussams and Leaton (2017, 24)

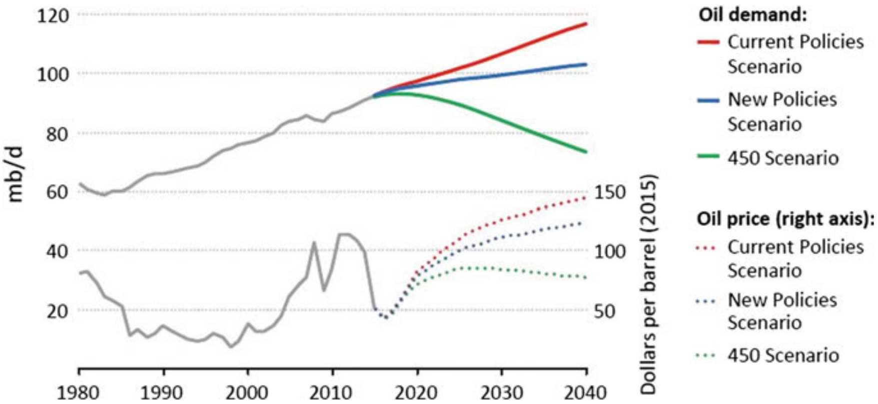

Fig. 4.3 World oil demand and price across three IEA scenarios. *Notes* The Current Policies Scenario assumes no changes in policy. The New Policies Scenario takes account of broad policy commitments, even if these plans have not yet been implemented. The 450 Scenario corresponds to a 50% chance of keeping global warming within 2 degrees. *Source* IEA (2016, 110)

assumes "overshoot", with atmospheric concentrations actually reaching higher levels than 450 parts per million (IEA 2015, 5). In any case, and without relying on unproven and potentially dangerous negative emission technologies, energy sector CO_2 emissions need to fall to zero by 2060 for a 66% chance of 2 degrees (IEA 2016, 75).

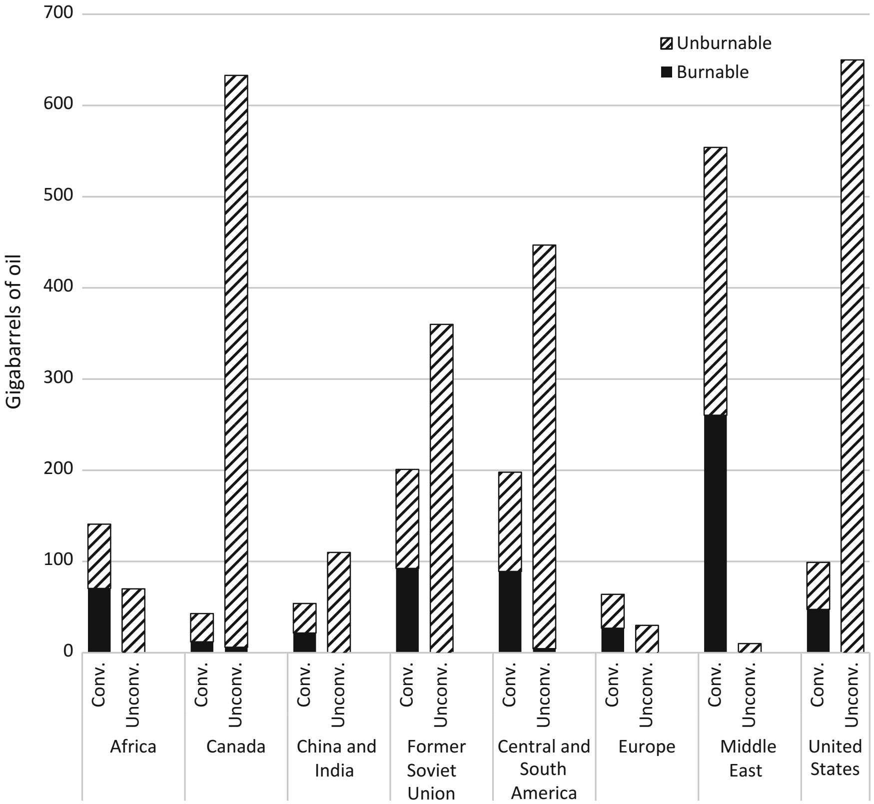

Fig. 4.4 How much oil is unburnable in a 2 °C scenario before 2050? *Note* "Conv." and "Unconv." stand for conventional and unconventional oil resources respectively. *Source* Author's creation based on data from McGlade and Ekins (2015)

Needless to say, climate mitigation action has huge implications for the fossil fuel industry. To have a 66% chance of staying within the 2 °C bounds, around 30% of global oil reserves are deemed "unburnable" by 2050, even if one assumes widespread adoption of carbon capture and storage (CCS) (McGlade and Ekins 2015). Figure 4.4 shows the geographical distribution of unburnable conventional and unconventional oil reserves up to 2050 in a 2 °C scenario with CCS. This study suffers from restricting the period to 2050. What really matters is that post-2011 cumulative emissions stay below 270 billion tons of carbon *forever* (Millar et al. 2016). Still, the basic insight that the bulk of oil reserves should stay in the ground remains valid. Canada should not touch any of its tar sands, the US should leave its tight oil reserves in the ground, while the Arctic should be left unexploited.

4.5 The Impact of Peak Oil Demand on Private Oil Companies

The history of capitalism can be read as a large sequence of what Schumpeter called ‘creative destruction’ (Schumpeter 1942). Technological innovation has disrupted many previous industries and corporations that failed to adapt have gone bankrupt, as new ones have entered the market. Recent examples are Kodak, the world’s iconic film company, which filed for bankruptcy in 2012, and Research in Motion, which produced the once ubiquitous BlackBerry. Both companies completely missed the rise of new technologies, which made their offerings obsolete. Big oil companies could be facing a ‘Kodak moment’ as the industry is disrupted by the growing electrification of transport.

The corporate landscape of big oil has exhibited a remarkable degree of stability during the twentieth century. Many of the biggest oil corporations still active today, like ExxonMobil, ConocoPhillips and Chevron are actually descendants of Rockefeller’s Standard Oil Company, which dominated the US oil industry in the late nineteenth century until 1911, when it was broken up by the US Supreme Court for violation of antitrust laws. Some parts of Standard Oil ended up with British Petroleum (BP) and Royal Dutch Shell.

The incumbent oil companies have responded in different ways to the rise of renewables and the specter of oil demand peaking well before supply. Some companies are still very much in denial that their business is being disrupted. ExxonMobil, for instance, projects demand for liquid fuels to climb as high as 20%, to 112 million barrels per day by 2040 (ExxonMobil 2015). Shell, on the other hand, believes that shifting consumer preferences and technological shifts could impact its business. In a sharp departure from other oil majors, Ben van Beurden, Shell’s chief executive, recently said that oil demand could peak in the second half of the 2020s. Earlier, Shell’s chief financial officer had said that peak oil demand could happen in just 5 years—that is, in 2021 (Katakey 2016). In general, the European majors have been more proactive and the American companies more reactive on the issue of climate change and the rise of renewables. This is tied to the differing institutional contexts and company histories (Skjærseth and Skodvin 2001; Levy and Kolk 2002).

Oil companies have in recent years been confronted with greater public pressure to address the possible disruptions to their business model from climate policies and the concomitant rise in renewables. A global divestment campaign has sprung up, leading schools, universities, hospitals and charities to disinvest their funds from fossil fuels. It is modeled after earlier divestment campaigns such as the ones against the tobacco industry or Apartheid. Yet, a key difference with prior campaigns is that there might be a strong business case for carbon divestment. If governments get serious about limiting global warming to 2 degrees, a lot of current reserves of the oil majors are to be left in the ground. This means that the valuation of those companies is inflated, creating the risk of a ‘carbon bubble’—an investment bubble that would arise if shares in fossil fuel companies would become ‘stranded assets’ in a climate-constrained world (Carbon Tracker 2011; Ayling and Gunningham 2017). As of June 2017, a total of 5.45 trillion US dollar had been divested from the fossil fuel industry. Among the institutions divesting figures Norway’s oil-based wealth fund, the world’s largest sovereign wealth fund.

In recent years shareholders and non-governmental organizations (NGOs) have called on IOCs to publically disclose the risks posed by climate change to their business models. Oil giants Shell, BP, Exxon have supported shareholder resolutions for greater transparency of the financial risks related to climate policy and the shift to renewables. In April 2015, the G20 asked the Financial Stability Board, an international body that monitors the global financial system, to develop a tool that can be used by corporations to disclose climate-related financial risks. From a legal perspective, fossil fuel companies that fail to be transparent about the damage their operations pose to the world’s climate could be liable in the same way as tobacco companies were for not telling the truth about the health damages from smoking (Olszynski et al. 2017). Exxon is currently under investigation in the US because it knew of the dangers of climate change since the mid-1980s but it kept on sponsoring climate denial campaigns and allegedly misled regulators and investors (Barrett and Philips 2016).

Most of these companies are in favor of some form of carbon pricing. Putting a price on carbon would especially hurt coal, the most carbon-intensive fossil fuel, and less oil and natural gas. A host of European majors (BP, Shell, BG Group, Eni, Statoil and Total) in June 2015 sent letters to the UNFCCC and the President of the COP21 Paris conference, as well as to the media, calling for the establishment of carbon pricing where it does not already exist and an international framework to link different carbon markets (Lund et al. 2015). It is worth noting that major American oil companies advocated against President Trump’s withdrawal from the Paris Agreement (Nussbaum and Carroll 2017). At the same time, however, oil companies are also involved in other advocacy efforts that could be seen as undermining climate action. Chevron, for instance, has expressed unease with California’s ambitious climate policies (Nasiritousi 2017).

Many oil companies are cleaning up their energy portfolios by investing more in natural gas, which creates less carbon dioxide than oil when burned. Shell’s 2016 takeover of BG Group, a British firm with large gas reserves, is a case in point. Others are early movers into the renewable industry itself. Dong Energy, Denmark’s largest energy group, clearly leads the way. Originally a state-owned oil and gas company, over the past years it has established itself as a renewable energy giant, particularly with regard to offshore wind farms. In 2017, it sold off its oil and gas business (Magew 2017). Total offers another example. In 2011, it acquired a majority stake in SunPower, one of the world’s biggest solar firms, and in 2016 it acquired French battery specialist Saft as well as Lampiris, a Belgian supplier of gas and renewable energy.

It remains to be seen to what extent these moves mark the advent of a new era for Big Oil. The example of BP offers a cautious tale about whether this bet on renewables will be sustained. In 2000, BP Amoco launched a marketing campaign, in which it branded its name as “beyond petroleum.” That strategy has now largely been abandoned. BP pulled out of solar power and shut down its advanced biofuels research program in 2014. It tried to sell its US wind operations but held off when it could not get a good enough price. Going even back further in time, Exxon was even a global leader in solar power research in the 1970s and 1980s (Crooks and Stacey 2016).

In sum, it is clear that the transition away from oil will wreak havoc on the oil companies. A prolonged, and possibly indefinite slump in oil prices will make the industry an ex-growth sector, with serious consequences for the availability of capital and labor in this sector. As Cairns (2014, 84) observes: “Prospective professionals, especially more promising minds, may shy away from training in an industry that is expected to be subject to increasing taxation, reduced rents, and societally mandated attempts to develop substitutes for its product.” Early movers into alternative businesses (renewables and batteries research and manufacturing, hydrogen, carbon capture and storage, nuclear energy) might be able to transform themselves and survive the transition to a post-carbon society; others are likely to be less successful. However, IOCs are not the only actors who will be negatively affected. As the next section delineates, countries that depend heavily on oil export revenues will be hit the hardest.

4.6 The Impact of Peak Oil Demand on Oil Exporters

The transition to a society that is less based on petroleum and more on renewables will affect oil-exporting states in various ways. Table 4.1 gives an overview of the top-20 oil exporting countries. Next to oil export figures, it gives an indication for how dependent these countries are on oil export revenues. A higher figure generally means that these countries have a less diversified economy, so this figure can be used as an indirect measure of the size of a country’s non-oil economy. On this basis, the major exporters can be loosely grouped into three classes. *Extremely dependent economies* are dependent for more than 30–50% on oil rents (e.g. Saudi Arabia, Kuwait, Iraq and Oman). *Highly dependent economies* have a dependency rate of around 15–20% (e.g. United Arab Emirates, Iran, Venezuela and Algeria). *Medium dependent economies* is a class of countries whose GDP hinges for about 10% on oil revenues (e.g. Russia, Nigeria, Kazakhstan and Qatar).

The table also includes another metric, oil income per capita. Instead of relating oil revenues to GDP, which introduces all sorts of biases (Ross 2012, 15–17), this indicator relates oil revenues to the population size. It tells something about “how many oil dollars a regime can direct at each citizen, for public goods, patronage, or coercion” (Smith 2012, 210). The combination of high oil rents and high oil income per capita typically marks the situation of a “rentier state”: a state where the government relies heavily on external, non-tax revenues from the export of natural resources, especially oil and gas (Mahdavy 1970; Beblawi and Luciani 1987; Anderson 1987). Rentier states have an implicit social contract in which rulers tend to use their oil revenues to “buy off” support from the population. Democratic input

Table 4.1 Key indicators of top 20 oil exporters

Country	Oil exports (mb/d)	Oil rent (% of GDP)	Oil income per capita	OPEC member?
Saudi Arabia	7.38	37.67	7800	Yes
Russia	4.78	8.46	2080	No
Iraq	2.83	39.87	1780	Yes
UAE	2.50	20.36	14,100	Yes
Canada	2.23	1.16	2530	No
Nigeria	2.11	9.43	370	Yes
Kuwait	2.04	51.95	19,500	Yes
Venezuela	1.81	14.47	2130	Yes
Angola	1.66	28.39	2400	Yes
Iran	1.49	18.44	1600	Yes
Kazakhstan	1.38	10.83	2370	No
Mexico	1.27	3.62	610	No
Norway	1.62	5.24	13,810	No
Oman	0.82	34.38	7950	No
Algeria	0.70	15.24	1780	Yes
Azerbaijan	0.68	20.62	2950	No
Colombia	0.67	4.58	430	No
Brazil	0.60	1.56	240	No
United Kingdom	0.60	0.50	150	No
Qatar	0.56	10.55	24,940	Yes

Notes Oil exports are the averages for the period 2012–2016. Oil rent figures are the averages for 2012–2015, except for Venezuela (2012–2013 average) and Iran (2012–2014 average). Oil income per capita shows the estimated value of oil and gas produced per capita in 2009

UAE = United Arab Emirates

Sources OPEC (2017, 60), BP (2017), Ross (2012)

from society is thus sacrificed in exchange for a share of the extractive wealth accrued through foreign sales of crude. Those who do not accept this so-called "rentier bargain" are confronted with the strong repressive apparatus affordable to the rentier state (Gray 2011; Ross 2012). The reliance on oil wealth thus gives these states a large degree of autonomy vis-a-vis their citizenry, and it is often associated with incoherent economic policies, the entrenchment of crony capitalists and military elites, and the decline of agriculture and industry through a process known as the 'Dutch disease' (Gelb 1988; Schwarz 2008; Morrison 2009; Ostrowski 2013).

A wide range of energy-economy models forecast losses to the members of the Organization of the Petroleum-Exporting Countries (OPEC) and other exporters if oil demand falls (e.g. McKibbin et al. 1999; Bartsch and Müller 2000; Barnett et al. 2004; Bauer et al. 2016; Waisman et al. 2013). Some studies argue that OPEC countries will gain rents, in the order of a few percent, due to atmospheric CO_2 stabilization targets. The explanation is that conventional oil reserves are cheaper to produce and have less carbon content than unconventional reserves (such as Canadian tar sands or shale oil) and most of their liquid substitutes. Yet, ‘if climate policy is implemented through energy efficiency standards and substitution to renewables, then energy demand will drop, but the price of oil will not increase’ and so OPEC will not gain (Persson et al. 2007, 6347; Johansson et al. 2009).

A shift away from oil to renewables creates three separate investment risks for the energy industry: ‘the extent of existing fossil fuel reserves that will be left unexploited (‘*reserves left in the ground*’ or ‘*unburnable fossil fuels*’); the capital investment in fossil fuel infrastructure which ends up failing to be recovered over the operating lifetime of the asset because of reduced demand or reduced prices (‘*stranded assets*’); the potential reduction in the future revenue generated by an asset or asset owner assessed at a given point in time because of reduced demand or reduced prices (‘*carbon bubble*’)’ (IEA and IRENA 2017, 106).

A crucial question for the future is whether petrostates are doomed to face economic and political collapse, or whether they can stave off some of the worst consequences of the shift away from oil and make a smoother transition to post-rentier states. This question is taken up next.

4.7 Can Petrostates Adapt to a Post-Oil World?

The rise in renewables is not something that is happening in some distant future, but it is happening now and is transforming energy markets and systems across the globe. The uptake of technologies typically follows an S-curve, which means that the global spread of EVs, solar panels, et cetera might accelerate in the near future. Oil rentier states are likely to experience economic hardship and political turmoil, as their oil revenues fall and their social contract falls apart. The downturn in global oil prices since 2014 provides a harbinger of things to come. After a long period of high and stable oil prices between 2011 and 2014, oil prices began to decline in the summer of 2014 due to sluggish global demand and, especially, the enormous surge in shale oil production in the US. In the span of just four years, the shale revolution had added about 3 million barrels per day in oil production. The effects of this additional volumes were long masked by unplanned outages in producer states, but they finally began to influence the price from July 2014. The decision by OPEC not to cut production in November 2014 only added to the global supply glut and the downward pressure on the oil price.

The oil price drop is related to structural changes on the supply side (the shale revolution) and the demand side (shifting consumer preferences, the secular stagnation of the economy, and the rise of alternative energy). While this does not mean that the oil business is no longer a cyclical business, the oil market is unlikely to return to the status quo ante. As the shift away from oil progresses, the market will go through a long-term decline. The oil price will continue to exhibit the boom-bust pattern that has always characterized the petroleum market, but the long-term trend will be downward.

The price fall since 2014 has exposed much of the economic vulnerability of the oil rentier states. Oil prices plunged by 77% from June 2014 to January 2016. All petrostates have experienced economic hardship (Van de Graaf 2016), and those with pre-existing (e.g. Venezuela where the oil sector has been mismanaged under Chavez) or other significant problems (e.g. Russia which faces sanctions from the West since the 2014 Ukraine crisis) have had a particular difficult time. Venezuela has hovered on the brink of bankruptcy, while Russia's economy shrank two years in a row (2015 and 2016). In early 2016, countries such as Azerbaijan and Nigeria sought emergency loans with the International Monetary Fund and the World Bank. Looking at how these petrostates responded to the crisis might be illustrative of what options they have at their disposal in the longer term, when oil is gradually displaced by renewables. Here, we discuss three strategies: racing to sell oil, preserving oil rents by curbing production, and domestic economic reform.

4.7.1 Strategy #1: Racing to Sell Oil

For decades, oil exporting countries have lived under the basic assumption of Hotelling's rule of optimal extraction of exhaustible resources: the owner of oil can leave the resource in the ground as a physical asset, or sell it and invest the proceeds in the financial markets (Hotelling 1931). This view is turned on its head if oil demand peaks well before supply—for example, through governmental regulations that prohibit oil use or through the substitution of oil by other sources. The upshot of oil demand destruction is that oil, in effect, is no longer an exhaustible resource (Dale 2015). Producers will then find out that oil under the ground might someday be less valuable than oil produced and sold today. The future value of oil deposits is likely to decline and this anticipated depreciation puts pressure on the reserve holders to sell as much of their oil now and invest the returns in capital markets (Van de Graaf and Verbruggen 2015; van der Ploeg and Withagen 2015).

Situations where the oil-producing countries competitively reduce prices in order to make zero-sum gains in market share at each other's expense are generally referred to as 'price wars' (Fang et al. 2012). Price wars have occurred several times on the global oil market, most notably in 1986 when Saudi Arabia decided to flood the market with oil to enforce quota discipline within OPEC. More recently, OPEC's decision in November 2014 not to cut production in the face of drastically falling prices is widely interpreted as a price war against US shale oil (Van de Graaf and Verbruggen 2015). If the drop in prices is larger than the increase in a country's oil output, than oil revenues are bound to come down. Oil exporters such as Venezuela, Russia and Brazil need to balance their budgets and therefore often keep supply up even when prices are falling.

Of course, if producers engage in a race to sell as much of their oil as possible, they could foster a price collapse, which could lead to some recovery of the market for oil and may hook consumers to oil again. This is an example of what Sinn (2012) has termed the 'green paradox', according to which the introduction of climate policy is an incentive for oil exporters to accelerate the extraction of their reserves and, hence, exacerbate global carbon dioxide emissions. Yet, there are reasons to doubt whether conventional oil producers will be able to turn the tides of lower oil demand through accelerated oil extraction. Cairns (2014) shows that 'green paradox' concerns are overblown in the case of oil production. Oil producers simply cannot rapidly increase oil production as they desire because of natural and technical capacity constraints. The productivity of a well decreases after an initial period of capacity production through what is known as 'natural decline'. The shale industry operates on a much shorter time cycle but, by itself, it is not able to play the role of swing producer (McNally 2017). Moreover, shale oil is located at the mid to high end of the industry cost curve, even though the production costs have come down. Average oil play costs are currently at around 48–65 dollars per barrel. Under a scenario where oil demand comes down fast (e.g. aggressive climate policies), oil prices would probably not rise above 50 dollars per barrel, rendering the bulk of shale oil uneconomic (Harvey 2017).

4.7.2 Strategy #2: Preserving Oil Rents by Curbing Production

Oil producers may also attempt to cooperate and collectively attempt to agree on production quota to preserve their oil rents through higher prices. The coordination may be done among the fourteen members of OPEC, which currently supplies about 40% of the world's oil, or among any ad hoc coalition of oil producers. This is exactly what has happened in the oil market recently. In November 2016, OPEC agreed to cut output by 1.2 million barrels per day, its first coordinated production cut in more than a decade. Crucially, the cartel secured a reduction of 558.000 barrels per day from 11 non-OPEC countries, including Russia, Mexico and Kazakhstan. The reductions were supposed to take hold in January 2017 and last for 6 months. Yet, with crude prices stuck near 50 dollars a barrel for month, it soon became clear that the output cuts had done little to drain bloated inventories, so the 24-nation coalition decided in May 2017 to extend the cuts for another nine months.

There are two key reasons to doubt whether such a quota strategy would help exporters preserve their oil rents. First, OPEC countries have a poor track record of cartel discipline. A recent study found that OPEC countries cheated on their quotas a staggering 96% of the time in the period 1982–2009 (Colgan 2014). In sharp contrast to previous production cuts, however, OPEC demonstrated remarkable compliance with the quotas. This is partly due to Saudi Arabia cutting by more than agreed. The Saudis want higher prices because of the planned initial public offering (IPO) of their oil industry's crown jewel, Saudi Aramco. The 11 non-OPEC countries have implemented only two-thirds of their promised cuts so far. There is little reason to believe that OPEC countries, let alone a much broader coalition of exporters, will suddenly demonstrate much higher compliance rates than the ones recorded in the past.

Second, OPEC might be well placed to stabilize the market in response to *temporary* shocks to supply or demand, but it is not able to balance the market in response to *structural* shifts that disrupt the oil business. For example, at the height of the great recession in 2008, as oil prices plunged from 145 to 35 dollars a barrel, OPEC reduced supply by nearly 3 million barrels per day, stabilizing the market and boosting prices. On the supply side, as the Arab Spring caused significant turmoil in several oil producers in the Middle-East and North Africa, other OPEC producers—most notably Saudi Arabia, Kuwait and UAE—increased their supply to offset partially these disruptions (Dale 2015). These were more instances of crisis management than of genuine market management, however (McNally 2017). Saudi Energy Minister Khalid Al-Falih echoed that view at a speech in March 2017, when he said:

> OPEC remains an important catalyst to the stability and sustainability of the market… but history has also demonstrated that intervention in response to structural shifts is largely ineffective… that's why Saudi Arabia does not support OPEC intervening to alleviate the impacts of long-term structural imbalances, as opposed to addressing short-term aberrations…. (Al-Falih 2017).

The adoption of a laissez-faire policy by the Saudi oil minister Al-Naimi at a notorious OPEC meeting in November 2014, defying wide expectations that the oil producers would cut supply, has been interpreted by some commentators as proof of OPEC's demise. This view is misguided for at least four reasons: (1) OPEC never really acted as a cartel, let alone a powerful one; (2) thanks to its cheap production costs, OPEC's oil will remain competitive in a low-cost environment; (3) the group has always proved to be flexible and resilient to major external shocks; and (4) OPEC is still attractive to its member states, most notably as a source of prestige, as is illustrated by the recent re-entries of Indonesia (a net oil importer, which has left the organization again in 2016) and Gabon (Van de Graaf 2017).

4.7.3 Strategy #3: Domestic Economic Reform

Domestically, the responses of the petrostates can be grouped into two categories: measures aimed at short-term adaptation and policies geared toward long-term transformation of the domestic political economies. In terms of short-term adaptation, there are several measures that oil exporters can take during a low-price period. If they have made savings during the boom period, they can tap into their foreign exchange reserves, following the standard model of precautionary savings (Bems and de Carvalho Filho 2011). Saudi Arabia, for instance, sat on what looked like a comfortable 730 billion dollars in 2014, the result of windfalls reaped during the boom period of 2011–2014. However, it has burnt through these reserves at a rapid pace. By April 2017, the reserves had already dropped below 500 billion, eliminating much of the savings made after 2011 (Shahine 2017). Like other producers, Saudi Arabia also needed to borrow money, first through the local bond market and then also through international bonds. Its deficit swelled to a historic 15% of GDP in 2015, and the government began to implement (unpopular) domestic austerity measures, reducing fuel subsidies, raising electricity taxes and cutting public sector bonuses and benefits.

Needless to say, these are politically sensitive moves in a country where the social contract is such that the government redistributes oil wealth and the citizens acquiesce to the ruling of the Al Saud family in closed circles of power (Cordesman 2003; Hertog 2011). Yet, such measures—tapping reserves, austerity policies, borrowing from debt markets and currency revaluations (as Russia has done)—bring only short term relief. Actions such as these do not fundamentally change the nature of these oil exporters as rentier states. Even Saudi Arabia's (belated) move into the refining business will not bring much relief (Krane 2015). In the past, downstream integration was a useful strategy to mitigate the volatility of crude prices, but it is a futile strategy when oil demand starts to go into structural reverse.

Over the longer term, these exporters face the challenge of diversifying their economic base. 'Sowing the oil' to diversify the economy has been a longstanding goal for many oil exporters. There is sound evidence that export diversification is associated with higher long-term growth and that countries that get 'locked in' to dependence on a limited range of products do less well in the long run (Lederman and Maloney 2007; Gelb 2010). Diversifying the economy can overcome the 'crowding out' of other productive activities, usually the manufacturing sector, that often results from petroleum dependence (Sachs and Warner 2001; Karl 1997). It is one of the few strategies available for resource-rich countries to ensure economic growth beyond the point where their oil reserves are depleted or, indeed, world oil demand enters into structural decline.

The recent price fall seems to have stimulated more long-term thinking in a few petrostates. Take Saudi Arabia, the world's largest oil producer. In 2016, Mohammed Bin Salman, the recently appointed crown prince of Saudi Arabia, unveiled plans to offer up to 5% of Saudi Aramco, the state-owned oil company, in an initial public offering (IPO) planned for 2018. Its listing could become one of the largest IPOs ever. Oil minister Ali Al-Naimi was sacked in May 2016 after holding the post for more than two decades. Just days earlier, Mohammed Bin Salman had announced bold economic restructuring plans, dubbed "Saudi Vision 2030". The aim is to reorient the Saudi economy away from dependence on oil revenues by 2020, and towards a newly conceived private sector. In June 2016, Saudi Arabia approved its "National Transformation Plan", outlining a number of concrete initiatives to be implemented by various ministries to realize the aspirations of "Vision 2030", including increasing efficiency, diversifying the economy, cutting public spending, reducing subsidies, increasing the role of the private sector, and privatizing major public assets.

Several oil exporting states, particularly from the Middle East, are also trying to get into the renewables business, particularly the UAE with its flagship 'Masdar' project. Their drive for renewable energy is motivated by several factors. The demographic and economic boom of the Gulf oil producers during the past few decades have also made them major consumers of energy. Hot weather conditions and lack of natural water resources have necessitated the use of increasing amounts of oil and gas for power generation required to air-conditioned homes and offices and desalinate sea water. Replacing these fossil sources of energy with renewables, could free up more hydrocarbons for exports (Reiche 2010; Sultan 2013).

Even so, only few petrostates have managed to truly break free from their dependence on oil revenues. Malaysia and Indonesia have successfully diversified as manufacturers, while Dubai has attracted foreign investment in infrastructure, services and business thanks to the creation of a massive special economic zone (Gelb 2010). It is doubtful that these experiences can simply be copy-pasted by other large oil exporters. On a per capita basis, Malaysia and Indonesia never produced as much oil and gas as the members of OPEC (Ross 2012). The Dubai model of development is not easily reproducible because the country so heavily depends on expatriate labor and skills, with nationals constituting only 10% of the population (Gelb 2010).

4.8 The Geopolitics of Too Much Oil

For most of the past century, the geopolitics of oil have been guided by perceptions of *scarcity* (e.g. Stern 2016). The concept of “peak oil” is central to this dominant understanding of energy geopolitics. It was coined in the 1950s by M. King Hubbert, an American geophysicist working for Shell. Hubbert posited that, for any given geographical area, the rate of production over time would resemble a bell-shaped curve. The production of petroleum was thus projected to climb until it reaches a plateau, after which it would enter a terminal decline. When oil prices reached their all-time high in July 2008, there was a widespread belief that “peak oil” had finally arrived. The projections of ever-rising energy demand added to the belief that oil prices would keep on rising (Hamilton 2014), coupled with the rapid depletion of existing oil fields, were believed to only intensify the scramble for oil and gas reserves. The general expectation was that these developments would only inflate the power of OPEC and other big producers such as Russia (Klare 2009). Recent events such as the build-up of tensions over a group of oil-rich, disputed islands in the South China Sea are often interpreted as part of this global “race for what’s left” (Klare 2012).

This prevailing view of scarcity-induced conflict over oil and gas resources is flawed. Rather than facing an imminent shortage of hydrocarbons, the world still hosts plenty of oil and gas resources. Moreover, key shifts on the demand side are eating into oil’s global market share. Oil abundance is not a new condition. In fact, the perennial problem for the oil industry has always been to socially organize scarcity (Bridge and Wood 2010, 565). From the 1861 Oil Creek Association, over the monopoly of Rockefeller’s Standard Oil, the quotas of the Texas Railroad

Commission, the Seven Sisters oligopoly, and the would-be cartel of OPEC, the history of oil is littered with examples of producer attempts to curtail the supply of oil (Yergin 1991; McNally 2017).

To the extent that oil prices would remain “lower for longer” as oil is increasingly displaced by other fuels and renewables, we can expect to see more socio-political instability in countries that are heavily reliant on hydrocarbon rents. It is important to note that the oil price fall in the 1980s played a key role in bringing the Soviet Union to its knees, and a decade later low prices continued to cripple efforts by Russian President Yeltsin to liberalize and reform the economy (Helm 2017, 26). The level of vulnerability is the highest in the Middle East and North Africa, where there is a large share of relatively young people that all need to find suitable jobs, and where the state’s dependence on oil rents is the highest (see Table 4.1; de Jong et al. 2017). As Smith Stegen argues in this volume, the losers in a renewable energy world will be those countries with strong hydrocarbon lobbies that have offered few incentives for renewable energies.

Of the major oil producers, Saudi Arabia arguably has the most to lose. Its population has grown from 4 million in 1960 to 30 million in 2015. The median age is around 18. Keeping this young population content was already a big challenge for the Al-Saud dynasty and it is set to become only more difficult when oil prices start sliding (Helm 2017, 119–120). Iran, by contrast, has a lot of advantages. It has a much broader economic base, a longer tradition of trading, and lower fertility rates. Like Iraq, the country oil production is much under its potential due to years of sanctions (Helm 2017, 123–124). This might in the long run turn out to be an advantage, as these economies prepare themselves for a post-oil age. Russia is also a major loser from the shift away from oil. Even though it is less dependent on oil revenues than Saudi Arabia and some smaller Gulf states, its endemic corruption, autocracy and lack of an industrial base will leave the Russian economy in a precarious state when oil revenues dry up. When the Russian economy sinks in a post-oil future, “there will be a tension between the need for external enemies to play out the Russian nationalism theme and the lack of money to pay for further adventures” (Helm 2017, 142).

The US comes out as a clear winner. Thanks to surging shale production and declining domestic demand, it is the only major power that is moving steadily towards energy self-sufficiency by the 2020s. While this is neither tantamount to autarky, nor will it insulate the US from the vagaries of the international market, it brings both economic and strategic benefits. Low energy prices have directly benefitted the US economy and the domestic energy revolution has also helped drive a decline in the US trade deficit, because of the reduced need for hydrocarbon imports (Dale 2015). Strategically, the US may want to revisit its old “Carter doctrine,” according to which it spreads a security umbrella over the Persian Gulf (O’Hanlon 2010; Klare 2016). This might be a good thing for the US since the Middle East has cost the US a lot of time, money and blood.

A possible US military retreat from the Persian Gulf might further create anxieties in China and other big Asian consumers over their energy security. In a future world of low oil prices and decarbonization, however, China might thrive in other ways. Thanks to the authoritarian power of the state, it has assumed top positions in the production of clean energy sources, and the withdrawal of the US from the Paris Agreement seems to have only strengthened its resolve in that regard. Like Europe and Japan, China is heavily dependent on oil imports and if these are displaced by homegrown renewables, this might lower these countries' energy import bills and reduce their strategic vulnerability to security of supply disruptions.

Clearly, oil abundance does not strip hydrocarbons from their geopolitical content. Quite the contrary, the existence of too much oil and gas could equally trigger geopolitical strife, conflict, and war. In a context of abundance, oil producers stand to benefit from situations in which their direct competitors cannot produce at full capacity, for some reason or another. The continued unrest in Libya, Syria, and Iraq, for instance, plays into the hands of all other oil exporters since it helps to keep oil prices high while also preventing large additional oil supplies from reaching the international markets. In a 'benign' interpretation, such outages are the result of purely internal political dynamics. In Libya, for example, oil production briefly restored after the 2011 toppling of the Gaddafi regime, yet strife among different clans and factions has since curbed the country's oil output.

A more 'malign' interpretation, however, allows room for deliberate destabilization of rival oil producers by outside forces. For example, the radical fighters known as IS (Islamic State) that have seized large parts of Syria and Iraq have allegedly received financing from Gulf petrostates. Emboldened by its own tight oil revolution and the prospect of exporting oil again in the near term, the United States has taken the lead in setting up oil sanctions against Iran and recently also against Russia, backed up by financial sanctions (Van de Graaf 2013; Van de Graaf and Colgan 2017). While it is questionable that the oil producers in the United States profit directly from these sanctions, they certainly helped to ease tensions in Riyadh about a US-driven oil glut in the wake of the fracking revolution (Weinberg 2014).

This interpretation of recent events illustrates how the geopolitics of energy could evolve in the coming years. The central stake would not be to conquer foreign oil and gas fields, but to unlock or close production fields for global markets in order to obtain the maximum revenues (rents) from the limited oil quota left over for human use in the coming decades (Verbruggen and Van de Graaf 2013). Oil producers would be catalogued, as is now already done quite often in an implicit manner, in 'friendly oil sources' and 'hostile oil sources'. The first category refers to countries that accept and protect foreign investment. It is centered on the axis US (with NATO allies)—Arab Gulf states (assembled in the Gulf Cooperation Council without Qatar). Hostile oil is led by Iran with a few committed allies (e.g. Venezuela). Many oil producers are drifting in between, several of them dazed by violent events or aggression.

4.9 Conclusion

Major changes are afoot in the world oil market on both the demand side and the supply side. The switch from fossil fuel to renewable energy and new low-carbon technologies is already underway, and is expected to accelerate. While climate policy is helping to steer the world in the direction of renewables, breakthroughs in technological innovation and cost reductions are propelling this shift forward. In other words, the rise of renewables depends ever less on the "push" of governmental regulations and ever more on the "pull" of market forces. The shift is disruptive to the oil industry and spells trouble for the major producers, who need to adapt or risk going out of business. The switch away from oil puts into question old assumptions of oil economics, including Hubbert's peak oil hypothesis and Hotelling's rule of efficient resource extraction.

In the short term, say to 2020, the oil markets are faced with oversupply as the shale industry and rising production from conventional producers such as Iran and Iraq has created a global glut. This has brought down revenues of oil exporters and international oil companies. The challenge for the longer term, say to 2030 and 2040 is summed up quite well by Dieter Helm:

> Longer term, new technologies in electricity generation, storage, and smart demand-side technologies, together with electric cars and the shift towards digitalization and new electricity-based technologies in manufacturing, will increase demand for electricity, but not fossil fuels (Helm 2016, 191).

Fossil fuels will still be used in the decades to come, but quite possible at lower prices. These tectonic shifts create an existential risk for many oil producing states. No petrostate has developed a credible "Plan B" in preparation of a post-carbon future. Oil exporters such as Venezuela, Nigeria, Brazil, and Russia are already experiencing economic havoc and political turmoil as a result of the sharp drop in crude prices since 2014. There are also wider geopolitical ramifications. The US comes out as a clear winner, but oil-import dependent economies such as China, Japan and Europe will benefit as well. Due to its large and young population and extreme dependence on oil revenues, Saudi Arabia will arguably be the biggest loser from the transition to renewables.

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Part II

Regional and Bilateral Energy Relations of Established and Rising Powers

Chapter 5
The Geopolitical Implications of a Clean Energy Future from the Perspective of the United States

Varun Sivaram and Sagatom Saha

5.1 Introduction

Energy has historically shaped geopolitics, the effect of geography on international politics. As a result, energy has shaped U.S. foreign policy. Since WWII, America has presided over the international order as its principal superpower. The United States has waged wars to thwart those who would disrupt the free flow of oil, built alliances to ensure its supply, and led institutions and coalitions in hopes of preventing nuclear proliferation while abiding peaceful use of nuclear energy.

Sometime this century, an energy transition is likely to take place, replacing with clean energy sources the fossil fuels that serve more than 80% of humanity's energy needs today (World Bank 2014). That transition could happen for many reasons. Countries around the world may decide to seriously confront climate change, various clean energy technologies could become much more affordable, and countries may be enticed by the energy security that accompanies domestically produced clean energy.

Even after this transition, energy is likely to continue shape global geopolitics, albeit in very different ways. This new energy landscape could see the United States lose its privileged position at the center of it all. In some ways, this might benefit America. For example, if it is less dependent on fossil fuels in the future, the United States may be able to retrench from the Middle East, saving both blood and treasure.

But the United States also has plenty to lose from shifts in the energy landscape. If Russia leaves the United States behind as a leading exporter of nuclear power,

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it could expand its coterie of client states in the developing world, eroding U.S. diplomatic leverage. And if countries around the world race to protect infant industries to capture a share of the growing clean energy economic pie, then the international trade regime that has brought America postwar prosperity could crumble.

The energy choices the United States makes will determine whether it can retain its central geopolitical role. By investing in energy innovation, the United States can command the advanced energy industries of the future, enhancing its energy security, amassing soft power, and shaping the future international order. And by leading worldwide action to confront climate change and commercialize clean energy technologies, the United States can build global goodwill that spills over to advance U.S. interests in other international fora.

This chapter explores five aspects of the global transition to clean energy, imagining hypothetical but plausible ways the world might unfold through 2050. The next section provides some theoretical background and explains the approach to selecting these five focus areas, into which subsequent sections dive. Finally, the chapter concludes with a discussion and set of recommendations to U.S. policymakers.

5.2 Theory and Approach

Theories of international relations are helpful in explaining many geopolitical aspects of energy in today's fossil-fuel-dominated world. These same theoretical tools are likely to be useful in helping to predict the geopolitics of a hypothetical future in which clean energy is much more prevalent. The literature comprises a wide range of theories, but to illustrate the explanatory power of the theoretical literature, it suffices to select two sufficiently different theories that are successful in explaining aspects of today's geopolitics of energy.

First, realism is a school of thought that posits a backdrop of international anarchy and holds that the state is the most important unit of analysis to understand international relations. The ultimate goal of a state is its own self-preservation, and to achieve it, a state will seek to maintain an advantageous balance of power in comparison with other states (Morgenthau 1993). Power comes in many flavors, including military strength, economic output, and diplomatic alliances (Mearsheimer 2001).

Realism succeeds in explaining many aspects of state behavior in relation to energy. For example, for over a half-century, the United States has expended considerable military resources to promote regional stability in the Middle East and secure international sea lanes to ensure the reliable production and safe passage of American fossil fuel imports. Because energy is vital to U.S. military and economic power, the United States is willing to invest heavily in securing its supply. Elsewhere, Russia has employed its domestic natural gas resource endowment to improve the balance of power among it and its neighbors, throttling or expanding the flow of gas to achieve its military, economic, and diplomatic goals (Yergin 1991).

Second, liberalism is a school of thought that differs sharply from realism but successfully explains some aspects of the geopolitics of energy where realism might fall short. Liberal theorists contend that the state is not necessarily the only, or even best, analytical unit to understand every aspect of international relations. Rather, other entities, like international institutions, can shape the behavior of states and choices (Moravcsik 1992). In addition to institutions, international norms can also influence states. Together, institutions and norms can facilitate mutually beneficial outcomes among states that would not materialize in the strictly anarchic setting, populated by purely self-interested states, that realists posit (Keohane and Martin 1995).

There is strong evidence to suggest that liberalism has explanatory power in some areas of the geopolitics of energy. For example, states cooperate under the auspices of the International Energy Agency to hold fossil-fuel reserves in anticipation of a global supply shock. And states also cooperate through the International Atomic Energy Agency, often voluntarily allowing external officials to inspect domestic facilities, to promote collective nuclear security.

Sharp disputes have arisen between these two schools of thought and among others in the literature. This chapter does not take sides in those debates. Rather, recognizing that these various theories have had explanatory success to date, this chapter seeks out aspects of the shifting energy landscape that could have geopolitical significance under one or more theories of international relations. For example, in a future dominated by clean energy, realism holds that states will continue to pursue their interests and seek an advantageous balance of power. Therefore, this chapter will delve into the opportunities and risks posed by clean energy to the military, economic, and diplomatic strength of states. By contrast, because liberalism holds that institutions and norms will continue to matter, this chapter will also explore ways in which they might lead to mutually beneficial outcomes in a clean-energy future—or ways in which their erosion might compromise those outcomes.

In exploring these geopolitically significant implications of a clean-energy future, this chapter will focus on what America's place in the world might look like and how that would affect its prosperity and security at home. Collectively, the five themes explored below could affect America's energy, economic, and national security as well as its relationships with other countries and with international institutions.

The first aspect of a clean-energy future that this chapter examines is merely an extension of the current literature on energy and geopolitics (Kalicki and Goldwyn 2005). Today, energy security figures prominently in America's continued military presence in the Middle East, but in the future the United States might sharply curtail its consumption of oil, reducing its exposure to price volatility arising from global supply shocks. This could change the military, economic, and political calculus of maintaining a strong presence in the Middle East.

The implications of more or less exposure to Middle East oil are well described by the existing literature, so evaluating a clean energy future amounts to little more than applying existing analytical tools to a new set of assumptions. But this chapter subsequently aims to do more as it takes up four other aspects of a clean energy future. Rather than just study the geopolitics of the absence of fossil fuels, it aims to study the geopolitics of a sharply increased presence of clean energy.

Clean energy includes nuclear energy, much more of which will be needed alongside renewable energy for the world to reduce its emissions in a cost-effective and timely manner (Cao et al. 2016). But if the U.S. nuclear industry continues to stagnate, and countries like Russia and China continue to invest heavily in their industries, then America will sit on the sidelines of the race to capture emerging nuclear markets and win diplomatic leverage. The section on nuclear energy envisions such a future and assesses the damage to U.S. strategic interests.

There are many other geopolitical implications of the rise of clean energy. For example, in a hypothetical future characterized by substantial renewable energy, countries are likely to have upgraded their power grids to accommodate intermittent wind and solar power. As the section on the power grid envisions, the United States may in the future have both a bigger grid, connected to those of its North American neighbors, as well as a smarter grid connected to the internet. These raise questions about how America will cooperate with its neighbors and what cybersecurity threats it could face from newly digital critical infrastructure.

Trade in energy is another geopolitically loaded subject, and this would remain true in a clean energy future. As the section on trade describes, the U.S.-led international trade regime might face pressure if countries begin to consistently flout trade rules. But rapid growth of clean energy might compel countries to do just that, to avoid being left out of a new distribution of energy haves and have-nots. If so, America would find itself at the helm of eroding trade institutions.

The fifth and final aspect of a clean-energy future that this chapter examines is the opportunity for the United States to lead international cooperation on clean energy and climate change. It could do so through established institutions like the United Nations Framework Convention on Climate Change (UNFCCC) or even brand new ones. Yet under the Trump administration, the United States has retreated from, rather than demonstrated leadership in, international climate and clean energy institutions.

This list is not exhaustive. The five themes, however, were chosen because each of them relates to core U.S. strategic interests. Many of them are specific instances of the general expectations for interstate energy relations in a clean-energy future predicted in Chap. 1, which include: a change in leverage away from fossil-fuel producers; regionalization of energy markets; increased importance of distributed energy resources; and growing economic competition in the clean-energy value chain.

To examine each of these five geopolitically significant aspects of a clean-energy future, this chapter will take a three-step approach. First, it will introduce the present-day context, focusing on early signs of future trends toward increased clean energy prevalence. Second, it will postulate a hypothetical scenario for the world in

2050, in which clean energy does in fact rise sharply, in order to make inferences about geopolitics and U.S. foreign policy in such a future world. Nearly all data for these scenarios come from the International Energy Agency (IEA) or other public sources; in some cases, additional calculations and forecasts from the academic literature are used. The third step is then to enumerate the implications for America's place in the world and its prosperity and security at home.

The chapter will conclude by briefly discussing lessons learned and making recommendations to U.S. policymakers.

5.3 The Fading Geopolitics of Fossil Fuels: New Dynamics with Established Powers

America's relationship with the Persian Gulf could drastically change by 2050 as it adopts clean energy. The United States currently maintains a strong military presence in the region, in large part to prevent disruptions in global oil supplies. But the American economy could be far less exposed to oil shocks in the future if it reduces its oil demand and develops stronger buffers against supply disruption.

The United Kingdom's withdrawal from the Gulf during the Cold War provides a template for how America's drawdown might look. In such a scenario, America might substitute its permanent presence for a lighter footprint and redirect its naval power elsewhere to address more pressing security concerns. Yet regional instability might deter a full U.S. withdrawal.

5.3.1 Context

America has long considered the Persian Gulf central to its national interest. Driven by concerns over global oil supply, President Franklin D. Roosevelt declared "the defense of Saudi Arabia as vital to the defense of the United States" in 1943, authorizing U.S. military aid to the Kingdom (Klare 2013). As the region constituted most of the world's non-Soviet oil at the time, a large supply disruption in the Gulf would have been disastrous to the United States (Glaser and Kelanic 2017).

Such a disruption came to pass when the Organization of the Petroleum Exporting Countries (OPEC) set an embargo on oil in 1973 (DOS n.d.). The price of oil in the United States quadrupled, imposing daunting costs on consumers and the wider economy. Between 1973 and 1975, U.S. GDP plummeted 6% and unemployment doubled to 9% (Hayward 2015). The U.S. economy is still exposed to oil prices today. Though it is difficult to estimate the direct economic cost of oil dependency, economists suggest a 10% increase in oil prices shaves 0.4% from GDP. If prices were to double today, economic output would shrink by 3% or about $550 billion (Glaser and Kelanic 2017).

Echoing FDR's doctrine, President Carter, in a State of the Union address, proclaimed that "an attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force." (Peters and Woolley n.d.a). He later created the Rapid Deployment Force, which would become U.S. Central Command (CENTCOM), America's unified U.S. military command responsible for the Middle East (Cordesman 1991).

Today, the U.S. military presence in the Gulf is still motivated by preventing both deliberate and unintended oil supply disruptions. The first mission is to ensure that countries in the region—in particular, Iran—cannot purposefully disrupt the flow of oil through the Strait of Hormuz. An extended closure would be devastating, blocking 20% of the world's oil supply (EIA 2012; Glaser and Kelanic 2017). The second mission is to backstop stability for major supplier-countries to guarantee steady production. Iraq's invasion of Kuwait alone cumulatively wiped 420 million barrels from world supply from 1990 to 1991 (Fattouh 2007). Either scenario—deliberate or unintended disruption to oil supply—would cause a surge in the price of oil, harming the U.S. economy.

To guard against these scenarios, the United States maintains roughly 35,000 troops in the Gulf, one-third of which are stationed in Kuwait (Katzman 2016). The remainder are positioned throughout the region in the United Arab Emirates, Oman, Bahrain, and Qatar. America's naval presence in the region is anchored by the Fifth Fleet, which patrols the Persian Gulf (Allen 2017). The fleet consists of several carrier strike groups, expeditionary strike groups, and a number of other ships and aircraft (Pike 2011a). The U.S. military also operates rotating Marine Expeditionary Units, brigade-size quick reaction forces for immediate crisis response (Pike 2011b).

It is difficult to attribute exactly how much the United States spends on protecting the flow of Gulf oil, given that many of these military assets also serve other purposes. However, experts estimate the cost at between 12 and 15% of the defense budget—roughly $90 billion dollars (Crane et al. 2009). Another assessment places U.S. defense spending attributable to oil imports at roughly $15 for each imported barrel (Hall 1992).

5.3.2 *The End of Middle East Oil Dependence*

In the future, the United States may not be as nearly vulnerable to oil price shocks. To understand the resulting geopolitical shifts, this discussion explores how the United States might reshape its foreign policy if by 2050 it shielded itself from swings in Gulf oil supply. Such a scenario is plausible because in the coming decades, U.S. oil consumption could very well plunge while America and other countries could improve buffers to supply disruption.

5.3.2.1 Decreased Domestic Demand

The lion's share of reduction in U.S. oil use would come from the transportation sector, which currently accounts for 70% of consumption (Glaser and Kelanic 2017). Oil demand from transportation has already been trending down for decades, so a drastic reduction is plausible. As one measure, U.S. petroleum consumption was lower in 2014 than in 1997 despite 50% economic growth in that period (EOP 2015). This reduction in the economy's petroleum dependence was largely because of higher fuel economy, though alternative fuels and electric vehicle (EV) adoption are playing an increasing role. Driven by lower technology costs and the need to combat climate change, all of these trends could accelerate through 2050.

First, substantial EV adoption would help the United States displace conventional vehicles. Though the U.S. is the second largest market for EVs, EV share of the U.S. vehicle market stands at a paltry 0.7%, suggesting significant room for future growth (IEA 2016a). Globally EVs are expected to account for 35% of new sales by 2040 (Randall 2016). In the United States, new sales could be as high as 50% by 2030 (Roelofsen 2016). Rapid global adoption of EVs could reduce oil consumption by 2 million barrels by 2028, creating oversupply equivalent to what triggered the 2014 oil price collapse (Randall 2016). Other developments like persistent increases in fuel economy for conventional vehicles would also decrease U.S. oil demand. Similarly, the emergence of cost-effective alternative fuels like advanced ethanol would increase oil's demand elasticity, making consumers more responsive to potential price increases.

Taken altogether, these trends could cumulatively cut U.S. oil consumption by 2 million barrels below today's level by 2040 and even more by mid-century (EIA 2016). Decreased oil consumption of that magnitude would greatly temper the effect on the United States of any disruption in Gulf oil supply.

5.3.2.2 Improved Security Alternatives

Second, this scenario sees the United States, along with several other countries, increasing the size of their strategic petroleum reserves (SPRs), limiting the effects of any supply disruption. The U.S. SPR holds up to 727 million barrels of oil, or roughly 150 days of import protection at current consumption (DOE n.d.a). The International Energy Agency (IEA) requires its members, who represent nearly half of worldwide oil consumption, to keep 90 days' worth of import cover, (IEA n.d.a). Collectively, these governments hold 110 days of global import cover, with an additional 119 days stored in the private sector (IEA n.d.b).

Though the U.S. government has not indicated plans to increase the SPR's capacity, it may do so in the future, as doing so would be cheaper than costs associated with protecting Gulf oil. At an oil price of roughly $50 a barrel, expanding the SPR by 50% would only cost between $10 and $40 billion (Glaser and Kelanic 2017). It is also plausible that other countries would develop their own strategic reserves by midcentury, collectively creating a more effective buffer to global supply distributions. Already, non-IEA countries are developing their own oil stockpiles. China's reserve reportedly already holds 600 million barrels (Mufson 2016). In this scenario, the world's cumulative stockpiles would increase relative to global demand. Importing countries would be able to shield themselves from supply shocks by coordinating stock releases to balance disruptions. Thus, oil prices would not experience significant volatility even in the event of a major disruption to oil supply.

5.3.2.3 Scenario Summary

Thus, the U.S. would be largely protected from an oil crisis in the Gulf, having satisfied two requirements: its economy would need less oil to function, and it would have better safeguards to mitigate supply disruptions that come to pass. And if global oil demand flags and Gulf production lags behind that of other regions, Gulf oil will be even less important to global oil markets and the U.S. economy. As these trends unfold, U.S. policymakers might finally decide to scale down America's military presence in the Gulf.

5.3.3 *Implications*

Something as simple as a strong push toward reduced defense spending—a subject of continuing debate in Congress—could force the U.S. to reevaluate the value of its military commitment toward securing oil flows. If limited, what exactly might America's force posture in the region look like in 2050? The British withdrawal from the Middle East provides one prominent example.

Until the late 1960s, the United Kingdom maintained a large military presence in the region chiefly to secure access to oil. Indeed, after World War II, Gulf oil supplies accounted for most of the world's non-Soviet oil and were therefore critical to British security and that of its European allies (Luce 2009). Britain maintained garrisons with air and naval support in Sharjah and Bahrain while also financing local police and military forces in Oman and Abu Dhabi (Sato 2009).

Despite this, the need to cut defense spending and stimulate the economy forced the United Kingdom to abdicate its special influence. In 1968, the British government announced a complete military withdrawal "east of the Suez" (Sato 2009). Most of the military was either redirected to Europe to confront the Soviet Union or cut altogether.

Dennis Healey, UK secretary of defense at the time, noted, "Although we have important economic interests in the Middle East, Asia, and elsewhere, military force is not the most suitable means of protecting them, and they would not alone justify heavy British defense expenditure" (Francis 2000).

With far lower dependence on Gulf supplies, American policymakers could reach a similar conclusion by 2050. A persuasive push to rein in ballooning defense costs—as in the United Kingdom—could compel the United States to withdraw from the Gulf. In fact, it may become strategically sensible for the U.S. to abdicate its role as security guarantor if that role is perceived as a responsibility and burden to secure supply for other countries. Support for maintaining America's military presence could evaporate when it becomes clear that India and China, not the United States, would actually suffer most from an oil supply disruption (Murtaugh et al. 2016). There may be little support for shouldering security costs that benefit other countries that are more dependent on global oil markets and Gulf production.

Yet the United States is unlikely to completely relinquish an active presence in the Gulf because of its commitments to combatting terrorism and checking Iranian aggression. Still, whatever military assets remain would require more specific justification than the broad fiat exercised today. America's role may mirror its current security posture in Sub-Saharan Africa, where it maintains a relatively small handful of bases and spends comparatively less on counterterrorism operations (Taylor 2014).

Concretely, the United States could forego its legacy of permanent military bases and naval assets in favor of a lighter footprint. America could pursue its non-oil-related strategic goals in the Gulf by relying on coalition building with regional and international partners. The president might deactivate the Bahrain-based Fifth Fleet or redirect it to the Asia-Pacific where it originally operated. In coming decades, China's growing influence in the region may drive the United States to build a stronger presence there.

However, the same trends of reduced oil demand that could reduce U.S. military interest in the region may also portend increased instability in the Gulf, intensifying the need for America's security guarantee. Many Gulf countries rely heavily on oil revenues to maintain security. Widespread clean energy adoption globally at the expense of oil and gas would place enormous fiscal pressure on these countries to slash budgets (Saha 2016). Nations unable, or unwilling, to do so could incite new waves of regional instability. If this occurs, the United States will have to decide whether to intervene.

5.4 Nuclear: Proliferation, Market Power, and Leverage

The rise of clean energy will have geopolitically significant implications beyond just the reduction in fossil fuel dependence. A good place to start is with nuclear power, the geopolitics of which have already been extensively studied. The tradeoffs between expanding nuclear energy and increasing the risk of proliferation are well documented, and America's strategic interests are clearly intertwined with the future of nuclear power.

Although the rest of this volume focuses on future increases in renewable energy, this chapter takes the stance that the most plausible future scenarios in which clean energy has mostly displaced fossil fuels include nuclear energy in the zero-carbon energy mix. Nuclear energy is currently the world's second largest source of zero-carbon energy (hydropower is the largest), and attempting to replace fossil fuels with clean energy without using nuclear power would require unprecedented and unrealistic growth rates in renewable energy (Cao et al. 2016). Although expansion of nuclear power has stalled in the developing world, emerging economies remain eager to adopt it to improve energy security, power economic growth, and reduce emissions and air pollution. Moreover, nuclear energy could be crucial to enabling the integration of large amounts of renewable energy by providing a load-following function (Jenkins and Thernstrom 2017).

Therefore, this section explores the potential geopolitical implications of rising global nuclear power deployment from a U.S. perspective, taking into account current indications of which countries are poised to become leading nuclear suppliers in the future.

5.4.1 Context

Though seemingly at odds, nuclear nonproliferation and support for civilian nuclear power have been pillars of U.S. foreign policy for more than half a century. In 1953, President Eisenhower gave his “Atoms for Peace” speech to the UN, in which he advocated for an international agency to both control and promote the deployment of nuclear power for peaceful use (Peters and Woolley n.d.b). Shortly after, Congress passed the Atomic Energy Act of 1954, which declassified U.S. reactor technology and opened research and development (R&D) to the private sector and other nations.[1]

The prospect of the rapid expansion of nuclear power raised strong concerns over the proliferation of hazardous fissile material. Many of the same technologies and materials used for civilian nuclear power—for example, highly enriched uranium (HEU)—can also be exploited for military use. In response to these fears, the International Atomic Energy Agency (IAEA) was created to supervise and monitor civilian nuclear power programs globally.

In collaboration with the IAEA, the United States has been a strong advocate for global non-proliferation efforts. U.S. nonproliferation policy centers on policing the flow of potentially dangerous nuclear materials, as well as deterring countries from pursuing nuclear weapons. The United States helped found the Nuclear Suppliers Group (NSG), which aims to prevent the transfer of nuclear material without IAEA safeguards. Under IAEA safeguards, countries file regular detailed reports and allow international inspectors to visit nuclear facilities to verify the reports (Nye 1981). In 2010, the Obama administration spearheaded the first Nuclear Security Summit (NSS) in an effort to secure loose nuclear materials globally and prevent nuclear terrorism. Between the last two summits in 2014 and 2016, an additional 20 countries have invited peer review of their nuclear security, including China,

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[1] See: Energy Reorganization Act Of 1974. Pub. L. No. 93-438, 88 STAT. 1233 (1974).

Nigeria, and South Korea and fifteen countries including India, Pakistan, and Ukraine have implemented physical security upgrades or acquired security or detection equipment (Nuclear Security Summit 2016).

Despite U.S. efforts to limit the spread of nuclear materials, proliferation remains a serious threat to national security. The global inventory of civilian HEU stands at roughly 137 tons, enough to construct 5000 nuclear bombs (NTI 2016a). And 24 countries currently have enough nuclear material for weaponization (NTI 2016b). Compounding this, hundreds of tons of nuclear material around the world are stored under inadequate security standards. Despite the potentially catastrophic effects of nuclear theft or sabotage, international law regarding nuclear security remains weak (NTI 2016b).

At the same time, the U.S. largely benefitted from the rapid expansion of atomic power. Until the 1990s, the United States dominated the market as the main supplier of nuclear technology to the rest of the world (NEI 2012). This commercial leadership allowed the United States to design international nuclear security standards and cultivate long-term partnerships globally.

Despite the United States' early lead, other countries have since raced ahead in the nuclear export market, reducing the U.S. to a minor player (WNA 2016). Russia and China are collectively building two-thirds of the world's new reactors while the United States only accounts for 7% (David 2014).

The rise of Russia as a leading nuclear exporter is particularly important from a geopolitical perspective, given the range of international issues on which it and the United States are at odds. Russia's nuclear exports have grown steadily through aggressive government support and technological innovation. In 2013, the Russian government earmarked $37.5 billion for Rosatom, Russia's state nuclear firm, for the next eight-year period in an effort to strongly position its exports in the marketplace (Carbonnel 2013). Because of Moscow's support and Rosatom's willingness to provide loans to poorer countries, Rosatom is able to sell its nuclear reactors at far lower costs than its international competitors (Thoburn 2015). By 2010, the development and construction of a nuclear plant in Russia was $2.9 billion, about 20–50% less than Western equivalents (Matlack and Humber 2010). All the while, U.S.-based companies have been beleaguered by heavy regulation, cost overruns, and competition from cheap natural gas. What was once the most successful American nuclear company, Westinghouse, has filed for bankruptcy, signaling the possible end of new nuclear reactor construction in the United States (Clenfield et al. 2017).

5.4.2 A Nuclear Renaissance

Despite the decline of nuclear in developed countries, the world might see nuclear energy rapidly grow in tandem with renewables in emerging economies. In such a scenario, developing countries would commit to adopting nuclear technology as they fuel economic growth and work toward achieving increasingly ambitious climate goals. And countries like Russia with advanced nuclear industries would continue to innovate, making atomic energy more attractive and less expensive while pushing exports for political gain. The following discussion lays out the details of such a scenario of the future.

5.4.2.1 Demand Growth in the Developing World

Admittedly, nuclear power has been in steady decline in parts of the developed world like the United States, Japan, and Germany. However, future demand in emerging economies could more than offset this decline (WNR 2015). In an effort to combat climate change, ten countries—including three without nuclear programs—are already incorporating nuclear power into their climate pledges made under the Paris Agreement (IAEA 2016). India, whose climate plans predominantly rely on solar deployment, plans to boost its nuclear capacity eightfold (IAEA 2016). So far, nuclear energy is the only globally available source of clean and reliable power that can economically operate at a high capacity factor and modulate its power output to complement renewables.

It is plausible for the world to dramatically increase nuclear power capacity by 2050. Indeed, that is good news, given that global nuclear capacity would have to double by 2050 to limit global climate change under current projections (IEA 2015). International commitments to confront climate change might well speed the deployment of nuclear power. The Paris Agreement requires countries to update climate plans every five years to be more ambitious starting in 2020 (Northrop and Krnjaic 2016). By 2050, 195 countries would have strengthened their plans seven times over, suggesting that even more countries may incorporate nuclear power into their climate pledges. In this future, most growth in nuclear would come from developing countries, which currently have non-existent or limited nuclear power programs. And most of those emerging economies would be in Asia, which is already expected to increase nuclear generation sixfold by 2040 (EIA n.d.a).

Firms and countries are already investing in commercializing new nuclear technologies, which could open vast, new markets to nuclear power. In particular, small modular reactors (SMRs) could help civil nuclear programs thrive globally in coming decades. SMRs are nuclear reactors roughly one-third of the size of current plants (DOE n.d.b). These new reactors—compact and factory-fabricated—circumvent many barriers that prevent less developed countries from adopting nuclear power today. SMRs require lower initial capital investments, have greater scalability and siting flexibility, and can be transported by truck or rail (DOC 2011). Simply put, this means that nuclear power could be sited in countries that currently have financial and geographical barriers (DOE n.d.c). They are also much safer than existing reactors, which have sparked public fears.

And light-water SMRs may provide a bridge to the commercialization of the next generation of post-LWRs known as Generation IV reactors. These reactors are designed to be inherently safe and resistant to meltdown. Moreover, they can be more efficient, cheaper, and consume rather than create nuclear waste. SMRs and

Generation IV reactors alike could enable more renewable power because they are designed to quickly increase and decrease power output. As more intermittent renewable power is added to the grid, power generators that previously could operate as “baseload” sources will have to become dynamic, able to vary their power output to avoid blackouts and negative pricing. Generation IV reactors are expected to come online starting in the 2030s (NEA 2014).

In this scenario, by midcentury, new nuclear technologies would mature with demonstration and become more cost-effective through learning and production effects. Countries around the world would deploy advanced reactors, multiplying the overall number of nuclear sites and expanding geographic distribution of reactors. By 2050, it is easily possible that more than one-third of countries would have at least one nuclear reactor (Donovan 2015).

5.4.2.2 A New Nuclear Suppliers Club

Russia will likely be a leader, alongside China, in the world’s burgeoning nuclear export market. Because Russian market power carries the most serious geopolitical implications from the perspective of the United States, this discussion focuses on Russia rather than China.

Rosatom already has export orders valued at more than $300 billion, 60% of the overall market, for 34 plants in 13 countries (WNA 2017). U.S. exports will remain uncompetitive unless Congress incentivizes investments in R&D and deregulates the cumbersome export approval process. Simply negotiating a nuclear cooperation agreement with the United States can take several years (CSIS 2013).

Russia’s market share will expand as long as the Kremlin considers it a matter of state policy. Over the last several years, Russian President Vladimir Putin has embarked on a series of international tours to sign nuclear power deals to shake off isolation after Crimea’s annexation and undermine U.S. diplomatic efforts (Chandler 2015). So far, Rosatom has already signed broad agreements or memoranda of cooperation on nuclear power with a variety of countries on nearly every continent (see Fig. 5.1) (Stratfor 2015). Russia is also racing ahead in the innovation race with plans to deploy two Generation IV reactors domestically by 2025 (WNN 2016). The combination of favorable financing and advanced technology could sustain Russia’s competitive edge for decades to come.

5.4.2.3 Scenario Summary

In this scenario, at least one-third of all nations would have a nuclear reactor by 2050. Most added nuclear capacity would be built in the developing world, specifically in Southeast Asia and the Middle East where agreements have already been signed. In this future, Russia would be a leading exporter of nuclear reactors. The amount of unsecured fissile material through 2050 would multiply, significantly increasing the risk of nuclear terrorism.

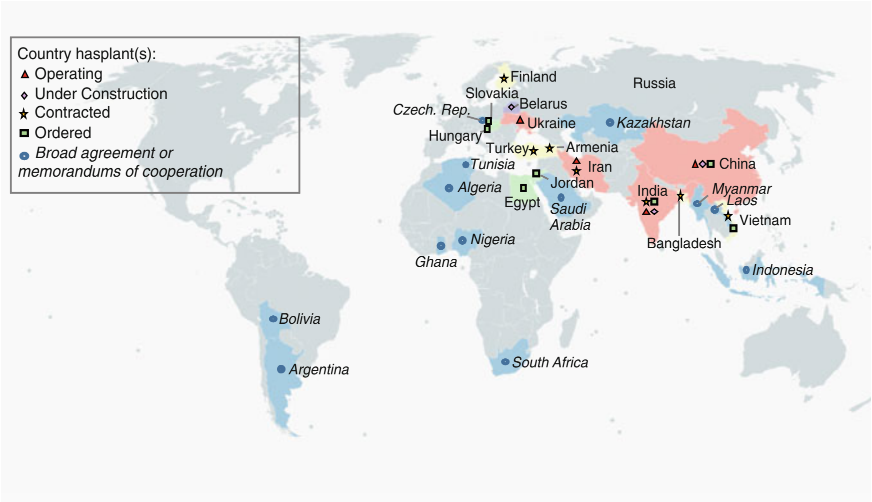

Fig. 5.1 Russian exports of nuclear power plants (2015). *Source* World Nuclear Association (WNA)

5.4.3 Implications

The resulting proliferation of nuclear material would create security risks for the United States, as well as its allies around the world. In response, the United States might try to invest abroad to help countries secure their nuclear stockpiles, an expensive proposition. It might also try to lead international fora to develop stronger nonproliferation standards.

But Russia, empowered by its booming nuclear exports, may be able to stymie these efforts as well as America's diplomatic agenda more broadly. Given the undesirable menu of choices the United States would face, the most pressing priority for America to undertake should be to revitalize its domestic nuclear industry and regain its status as a global nuclear powerhouse, with all the attendant diplomatic and security benefits.

5.4.3.1 Nuclear Proliferation

The widespread proliferation of nuclear material to less secure locations could grant terrorist organizations more targets for nuclear theft. Today, even though there are large quantities of unsecured materials, most of the world's civil nuclear stockpiles are sited in stable countries. By 2050, this may not be the case. How might America handle this emerging threat? U.S. support for Pakistan, an unstable country and nuclear power, offers one glimpse into how the United States might stem potential hazards.

Pakistan has the worst nuclear security of any country with weapons-grade fissile material (Oswald 2012). Its instability, fueled by poor governance and constant terrorism, provokes U.S. unease. In recent years, terrorist groups have been bold enough to mount raids on air bases storing nuclear warheads (Nelson 2012). The United States cooperates closely with the Pakistani government to prevent nuclear theft. The U.S. government has provided technological and financial assistance to Pakistan to help secure its nuclear systems (Cohen 2016). Though it is hard to quantify the entire scope of U.S. support, the United States has invested roughly $100 million in setting up nuclear security programs including sales and technology transfers from U.S. companies (Fair et al. 2010, 33). To ensure stability, the United States has also relegated human rights in Pakistan to a lower priority (Fair et al. 2010, 142).

By 2050, tens of other developing countries may have ramped up their use of nuclear energy. Accordingly, America's relationship with those nations could mirror its current one with Pakistan. U.S. spending on nuclear security, including international programs, stands at $500 million, down from $800 million in 2012 (Bunn et al. 2016). If America chooses to be the world's patron of nuclear security, these costs could balloon rapidly into the billions. In such a scenario, the United States could need to provide funds to India, Indonesia, Saudi Arabia, Turkey, and parts of Eastern Europe simultaneously to improve the physical security of fissile materials (Bunn et al. 2016). Such a sum could be politically unpopular, especially if Russia profits politically and financially from exports without stepping up on nuclear security.

5.4.3.2 Nuclear Market Power

Not only would the United States face a heftier bill for safeguarding nuclear material around the world, but it might also run into obstacles if it tries to strengthen the institutional framework that governs international nuclear security. America could even find itself more diplomatically isolated on totally unrelated global issues.

As the world's dominant nuclear supplier, Russia would likely do little to improve global nuclear security standards. Its own lax standards are well-known. Instead, Russia could use its market power for political gain. The country already has a notorious history of using resource wealth as a tool of foreign policy. In 2005, Russia, the primary natural gas supplier for much of Europe, halted flows to Ukraine after the country elected Western-leaning President Viktor Yushchenko (Kramer 2006). Russia's nuclear industry is already showing signs that it could function similarly to foster and exploit dependency. This could threaten a broad range of U.S. interests globally.

The business model Rosatom employs provides a great deal of influence. The firm operates on a Build, Own, and Operate (BOO) scheme, which means the firm offers to construct nuclear reactors for developing countries even if they are unable to finance them on their own (Reuters Staff 2013). Under this model, Rosatom owns the plant and offers the full range of services needed for nuclear power from construction, financing, and maintenance. The process results in little transfer of technology or expertise. Instead, the result is that importing countries are reliant on Russia for a substantial part of their energy needs.

By 2050, Russia could use its market power to unduly influence importing countries' domestic politics. In many cases, countries with Russian nuclear reactors would be locked into using Russian fuel, giving the Kremlin leverage (Dobrev 2016). For some countries, this is already the case. Hungary, Slovakia, the Czech Republic, and Ukraine, which constitute a population of 80 million Europeans, are collectively dependent on Russian nuclear cooperation for about 42% of their electricity (Sharkov 2015). In Hungary, Rosatom plans to finance the Paks nuclear power plant, which supplies roughly 40% of Hungary's electricity. Hungarian Prime Minister Viktor Orban has since called for the EU to normalize relations with Russia (Than 2015). Into 2050, Russia could similarly influence major economic powerhouses and strategically important countries around the world like Turkey, Jordan, Saudi Arabia, Vietnam, and Indonesia.

As a result, U.S. security and international influence could suffer because of the new dynamics of the nuclear market. If Russia achieves primacy in the nuclear market, it could more easily oppose not only U.S. efforts to ensure nonproliferation, but also U.S. diplomatic interests broadly. If the United States attempted to convene countries to construct an updated nuclear nonproliferation regime, it could more easily be thwarted by Russia and its coterie of client states. A U.S. attempt to promote more stringent nuclear security standards in international fora like the IAEA, NSG, and NSS would require cooperation from the world's nuclear economies. Countries that receive Russian exports and benefit from laxer standards could disregard future multilateral meetings at Russia's request.

This principle could apply for other issues as well. Today, America opposes Russia's support of authoritarian regimes and misinformation campaigns globally. If its nuclear market power pans out, Russia could find itself with more allies in 2050 and the United States fewer. Therefore, it is vital that the United States invest heavily in bolstering its domestic nuclear industry to provide a counterweight to a potential nuclear oligopoly. To do so, the United States should dramatically increase federal funding for nuclear research, development, and demonstration to commercialize small modular and Generation IV reactors. It should also revamp its domestic regulatory framework and impose a price on carbon so that the domestic U.S. market can help revitalize the U.S. nuclear industry.

5.5 The Transition to a 21st Century Grid: Opportunities and Threats

The rise of clean energy in the United States is sparking a transition to a more interconnected and technologically advanced grid. The U.S. grid is likely to transform in two ways. First, to incorporate intermittent renewable energy, grids across North America could become more connected, integrating the U.S. and

Mexican grids in particular, and changing the security dynamics in the North American neighborhood. Second, the U.S. power system is likely to evolve toward a smart grid with a mix of distributed and centralized energy resources and complex power and communication flows between customers and the grid.

These twin transformations could be a mixed bag for U.S. security interests. First, greater integration could offer an opportunity for the United States to cooperate with its neighbors. But the advent of the smart grid could open more security vulnerabilities than it closes because of the proliferation of internet-connected devices and infrastructure. As a result, opportunities for adversaries to carry out cyber-attacks on the United States could increase.

5.5.1 Context

The U.S. electric grid comprises vital infrastructure that underpins the nation's economy. One of the greatest innovations of the 20th century, America's electric system evolved over the last century to offer greater interconnectivity to best deliver reliable and affordable power, mostly from central, fossil-fueled power stations. Looking ahead, grid expansion and interconnection will likely continue. But in addition, a new transformation could simultaneously take place—one in which the grid also becomes smarter and more decentralized to accommodate an increasing level of clean energy.

At the beginning of the 20th century, Americans received power from one of 4000 isolated utilities, which could only distribute electricity over short distances. But soon, utilities adopted alternating current (AC) technology, which can transport electricity over long distances. Once AC technology took hold throughout the electricity sector, utilities started to build larger, centralized power plants to serve broader swathes of customers (EIA n.d.b).

As power demand surged during the post-World War II economic boom, utilities interconnected their transmission systems to increase efficiency by reducing the amount of extra generation capacity required to be held in reserve and building larger, jointly-owned generating units to serve aggregate demand at lower cost. This integration resulted in three interconnected systems that service the eastern and western halves of the country and Texas.

The U.S. grid has similarly interconnected with northern neighbor Canada for the same benefits (see Fig. 5.2). The electricity systems between the United States and Canada today are highly integrated with more than 30 major transmission connections and roughly $3 billion in electricity traded between the two nations (DOE 2015). Around 10% of all Canadian generation capacity services U.S. customers. There are additional benefits as grid managers are able to optimize electricity generation on both sides of the border to ensure reliability and efficiency. In contrast, the United States engages in comparatively little cross-border electricity with Mexico (DOE 2015). Cross-border electricity trade with Mexico amounted to less than one-hundredth of a percent of total U.S. generation in 2013 (EIA 2013).

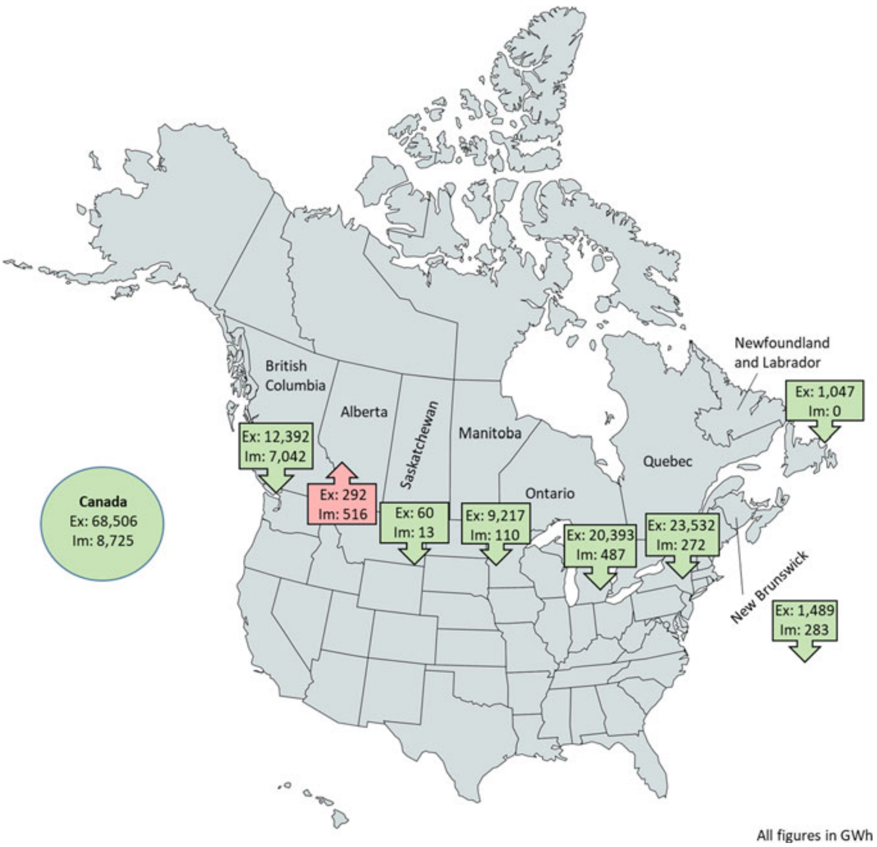

Fig. 5.2 Electricity imports and exports between Canada and the United States (2015). *Source* Government of Canada National Electricity Board

Recently, two overlapping types of resources have begun to upend the traditional model of central fossil-fueled power stations supplying the grid with power. First, the amount of renewable energy connected to the grid—mostly from large solar and wind farms—has dramatically risen in recent years. In 2015, wind and solar collectively accounted for two-thirds of new capacity added to the U.S. grid, and renewable energy now constitutes 13% of U.S. electricity generation (EIA n.d.c). A second, more incipient, trend is the rise of distributed energy resources (DERs). DERs are locally sited resources like rooftop solar or distributed batteries, fossil-fueled generators like natural gas micro-turbines, demand-side appliances like smart thermostats, and many more resources. As costs have fallen and firms have introduced new products on the market, distributed generation has more than tripled since 2010, with more than 645,000 homes and business using solar panels in 2015 (McBride 2016).

Both trends are straining the 20th century paradigm of the electric grid. The intermittency of renewable power output makes it difficult to match instantaneous supply and demand. Weather fluctuations affect nearly all solar and wind capacity and can sway output for seconds, hours, days, weeks, or even seasons, creating uncertainties beyond what the grid was designed to handle (American Physical Society 2016). And the rise of DERs threatens to overload distribution grids that were not designed, for example, to handle reverse flows from a customer's solar panels to the grid or to charge fleets of electric vehicles.

As a result, grid expansion and modernization became U.S. federal priorities, especially under the Obama administration. To deliver variable renewable energy from areas of plentiful wind and solar resources to urban demand centers—often hundreds or thousands of miles away—the Federal Energy Regulatory Commission established rules to boost investment in the transmission infrastructure and improve power reliability. Expanding the grid reduces the costs of integrating intermittent renewable energy, smoothing supply and demand volatility through aggregation, and reducing the reserve generation capacity needed to ensure power system reliability.

To improve the ability of the grid to handle more intermittent power and integrate DERs, the Department of Energy (DOE) has made the development of a smart grid—an automated, computerized power network utilizing two-way digital communications—a national priority (McBride 2016). Since 2010, the DOE has invested $4.5 billion in smart grid infrastructure (McBride 2016). Grid modernization could continue under President Trump, who campaigned on the promise of massive investments in national infrastructure.

5.5.2 A Twenty-First Century Grid

By 2050, America's electricity grid could be far more integrated across its borders and even more distributed. In this scenario, a single, highly integrated North American grid would emerge, and the U.S. would invest heavily in developing a smart grid.

5.5.2.1 An Integrated North American Grid

It is likely that variable renewable energy will be prevalent across North America by mid-century. Such a shift will drive Canada, the United States, and Mexico to interconnect their grids to a high degree to limit the costs of integrating renewables. The three countries have already planned to generate 50% of their energy from clean sources by 2025, a target that would be easier to achieve across a unified power system (Dlouhy and Keane 2016). And renewable power could be as much as 80% of U.S. electricity generation by 2050 (NREL 2012). Given the United States' thriving electricity trade with Canada today, the most salient opportunities to interconnect grids would be between the United States and Mexico.

U.S.-Mexico cross-border electricity has been historically limited because, until 2013, Mexico's electricity market was a state-run monopoly closed to foreign trade. However, at the end of 2013, Mexico reformed its energy sector, allowing for competition in the power sector and private investment from both at home and abroad (Robles 2016). So far, Mexico shares only 11 transmission connections with the United States, but the country already plans to add roughly 28,500 miles of new transmission lines by 2040 (IEA 2016b). And Mexico's Ministry of Energy has prioritized increasing international electricity interconnections with the United States in its long-term power sector strategy. These interconnections could link regions of Mexico with high solar and wind potential like Baja California with major urban demand centers like Los Angeles and San Diego; similarly, they could link the sun-soaked American southwest and windy Oklahoma panhandle with demand centers like Mexico City. So, by 2050, cross-border electricity trade with Mexico could flourish.

Although the low-hanging fruit is more interconnection with Mexico, there is some opportunity to further increase U.S.-Canada cross-border electricity trade. In particular, Canadian hydropower currently supplies just 1% of U.S. electricity demand, but has the potential to more than double (Canadian Hydropower Association 2014). If Canada fully developed its potential hydropower and exported half of its production, exports to the United States would rise tenfold (IEA 2014). And by constructing pumped hydro storage facilities, Canada could provide energy storage to enable the United States to increase its share of intermittent renewable energy, much as Norway plays the role of Europe's battery. Under the assumption that the United States will act to maximize its share of clean power, interconnection projects like the Great Northern Transmission Line, Champlain Hudson Power Express, and Montana Alberta Tie Limited could gain traction, speeding construction. Taken together, increased interconnection between the United States and both Canada and Mexico—as well as increased grid integration within the United States would lead to a North American super grid by mid-century.

5.5.2.2 A Smart, Decentralized Grid

Grid transformation will be driven by the rise of both variable renewable energy as well as distributed energy resources—much of it clean. Were these resources to all connect to a grid based on the 20th century paradigm, system costs would soar and reliability would suffer. Therefore, regulators and utilities around the country are likely to work together to invest heavily in smart grid technologies to enable the two-way flow of information between customers and the grid and improve grid operators' control and visibility over the distribution grid.

Smart infrastructure could be deployed on both sides of the customer meter. On the customer side, customers could install smart appliances, inverters, vehicles, and other intelligent electric loads and electronics. On the other side, utilities are likely to invest heavily in supervisory control and data acquisition (SCADA) systems to monitor and operate the grid more effectively. And the meters themselves are likely to change—smart meter penetration in the United States is already relatively high and expected to reach 80% by 2020, so by mid-century it could be practically universal and become even more internet-connected (Accenture 2016).

The overall number of "Internet-of-Things" (IoT) devices is expected to surge to 50 billion as soon as 2020, twice as many as in 2015 (FTC 2013). By mid-century, this figure could balloon to a trillion or more. This could enable a smart grid that replaces the current, centrally managed grids with complex bidirectional power flows and communications.

5.5.3 Implications

If the scenario described above plays out, the 21st century grid could create both opportunities and threats for the United States. First, greater integration of the North American power system could bind the continent together even as other traditional pillars of cooperation, like trade, fall. But second, the exponential increase in digitally connected grid devices could expose America's most critical infrastructure to assault. The shared infrastructure would have a subtle, but important, geopolitical effect on America's relationship with its neighbors, particularly Mexico. And the modern grid would expose the nation to threats from geopolitical adversaries globally.

5.5.3.1 Opportunities to Bolster Relationships with Neighbors

For decades, free trade has been the foundation of regional cooperation among the United States, Canada, and Mexico. In the future, this may not be the case. The Trump Administration has threatened to terminate the North America Free Trade Agreement (NAFTA) and has advocated for stronger tariffs. Such policies could severely damage America's relationship with Mexico.

Fortunately, in a scenario where the North American grid becomes deeply integrated, the required cooperation to manage this shared energy infrastructure could countervail the potential animosity. Joint grid management requires deep levels of cooperation. The seamless integration of the U.S.-Canada grid provides one example of how the United States and Mexico could need to cooperate in the future. Canada and United States both participate in the North American Electric Reliability Corporation (NERC), which sets reliability requirements and standard business practices. Both countries also work together on cross-border emergency response. For example, roughly 800 Canadian utility workers traveled to New Jersey to help restore power after Superstorm Sandy left 2.7 million Americans without electricity (DOE 2015). By 2050, the United States could have a similar relationship with Mexico. U.S.-Canada energy cooperation predates many of the axes of cooperation between the two nations considered fundamental today. The first interconnection between them predates NAFTA by almost 100 years

(Canadian Electricity Association 2016). New grid interconnections would require deep cooperation on standards, data sharing, and disaster planning to manage electricity flows and mitigate hazards.

The United States should seize the opportunity to shore up a potentially deteriorating relationship. Indeed, in the future, energy cooperation might become the most concrete axis of cooperation in North America, especially if free trade fades as the region's lynchpin of diplomacy. Such is the case in the Eastern Mediterranean where shared energy resources have prompted cooperation in an otherwise hostile region. In a rare example of geopolitical rapprochement in the Middle East, Israel and Turkey normalized ties in 2016 after Israel discovered significant maritime natural gas reserves that would require help from Turkey to explore (Sezer 2016). Though the relationship between the United States and Mexico might not be as strained yet, energy cooperation could serve as a stabilizing force to smooth over some tensions within North America. In difficult geopolitical neighborhoods, opportunities to improve energy security and mutual economic gain often prove to be catalysts for cooperation.

5.5.3.2 Rising Threats From Cyber Attacks

Unfortunately, the power grid of the future may also provide opportunities to those seeking to harm the United States. As smart grid technologies become more common, cyber access points to the grid will increase exponentially (McLarty and Ridge 2014). Compounding this, a broader array of devices, appliances, and systems—all able to send and receive information from the larger grid—could be connected to network control systems. Each digitally connected component of the smart grid is an access point to hack the grid and disrupt power flows. The result could mirror the leveling effect of nuclear weapons proliferation, which blunted the usefulness of America's conventional military capabilities. If the United States is asymmetrically exposed to cyber-attacks, the relative potency of its hard power could suffer.

Generally, utilities have kept electricity infrastructure safe so far by separating it from the rest of the internet. This may not continue as the smart grid emerges. Exploitable flaws have already been discovered in power generation sources like wind turbines and utility SCADA systems (McLarty and Ridge 2014). According to Michael Rogers, head of the National Security Agency and commander of U.S. Cyber Command, "it is only a matter of when, not if, we are going to see something dramatic," referencing a potential attack on critical infrastructure like power generation (Bordoff 2016).

Indeed, opportunities could increase for actors around the world to attack the U.S. grid. States with which the America has a tense relationship—like Russia, China, and Iran—are reportedly already probing the U.S. grid for digital vulnerabilities as a standard practice (Williams and Bennet 2016). Some of these countries have already demonstrated the ability to conduct large-scale attacks on power infrastructure. For instance, U.S. investigators confirmed that Russia used malware to cause a blackout for 225,000 in Ukraine in December 2015 (Volz 2016). Security experts have already demonstrated that two-way communications between the grid and smart grid technologies like smart meters can be used to shut down entire electricity networks (Steitz and Wolde 2014).

Despite mounting hazards, the U.S. government and private sector have done little to prepare for, prevent, or mitigate cyber-attacks. So far, there has been no major legislation on critical infrastructure protection and cybersecurity and security on IoT devices remains unregulated (McLarty and Ridge 2014; Schneier 2016). Local utilities, as well, have invested little in protecting electricity systems (Gahran 2016). As a result, the power sector is arguably the area of critical infrastructure most vulnerable to cyber-attack (Bennet 2015). Therefore, to protect itself, the United States should invest heavily in grid security alongside other investments to modernize the grid. Legislation like the Enhanced Grid Security Act of 2015 and previously proposed Energy and Water Development appropriations bills have been introduced in Congress advocating for such steps. Such legislation would task the development of advanced cybersecurity applications in the energy sector, implement cyber-testing and cyber-resilience programs, and fund R&D to shield the grid from cyber-attacks.

Although Congress has become increasingly partisan in recent years, protecting critical infrastructure from cyber threats abroad should be a clear bipartisan priority. Finally, U.S. regulators at both the federal and state levels should push utilities to become leaders, rather than distant followers, in designing cyber security protocols for the grid. Utilities can learn from enterprise software companies, which have developed software suites that offer easy, internet-connected access to numerous users while strictly enforcing a secure hierarchy of access privileges in which downstream nodes are firewalled from attacking upstream control points. Federally funded national laboratories, like the National Renewable Energy Laboratory, are already helping utilities move in this direction and should continue to accelerate this security transition (Sivaram 2016). The United States should also improve its own offensive cyber capabilities to deter adversaries from using their own.

5.6 Trading Blows: How the Rise of Clean Energy Could Provoke Global Trade Wars

Trade in energy is central to the global economy. Indeed, crude oil and natural gas today are two of the top three most traded commodities around the world. To mitigate the risks of energy dependence, the United States has historically developed alliances with exporters like Saudi Arabia whose wealth and geopolitical influence were built entirely through the energy trade.

In the future, the energy trade may well remain central to the global economy and continue to shape global geopolitics. But two major differences could distinguish the future from the present. First, the energy products being traded could instead be clean energy products—including solar panels, wind turbines, batteries, and nuclear reactor components—whose traded value by mid-century could rival that of fossil fuels today. And second, there would no longer be any inherent reason why some countries are exporters and some are importers. Although only some countries are endowed with natural fossil fuel resources, any country can participate in the manufacturing supply chain for most clean energy products.

If such a future materializes, trade disputes over energy may frequently erupt, endangering norms of free trade that have brought the United States immense prosperity. Because countries will want to reap the benefits of domestically manufacturing and exporting clean energy products, they may flout international trade rules against protectionism. Already, the United States has been embroiled in trade disputes over clean energy products with Asian countries even though clean energy composes a small fraction of global energy trade. In the future, such clashes could be much more frequent.

5.6.1 Context

Already, at the beginning of the 21st century, several disputes have emerged over the burgeoning global clean energy trade. Most of these disputes relate to China, which has raced ahead as the undisputed leader in manufacturing clean energy products—including solar panels, wind turbines, and batteries (Clean Energy Manufacturing Analysis Center 2017). Some disputes allege that the Chinese government has illegally supported its domestic industries; others arise from other countries seeking to protect their own industries to compete with China's.

First, the United States and other developed countries have accused China of illegally supporting its domestic clean energy industries. In 2012, the U.S. government accused Chinese solar companies of dumping below-cost, government-subsidized solar panels in the American market and responded with punitive tariffs (Daily 2012). In response, China retaliated with its own tariffs on U.S. polysilicon, the raw material used to manufacture solar panels (Li and Ma 2014). In 2013, the EU and China similarly almost sparked a trade war over illegal dumping of $25 billion worth of solar panels; the eventual settlement limited the volume of Chinese imports into Europe and set a floor on their price (Reuters 2016). In a separate dispute, the United States brought a case to the World Trade Organization (WTO) challenging Chinese government subsidies to domestic manufacturers of wind power equipment. Before the case was settled, China terminated the grant program (Asmelash 2015).

A second category of trade disputes involves countries seeking to build up their own domestic manufacturing capabilities by requiring WTO-noncompliant "domestic content" policies to compete with China to do so. In 2012, a WTO panel ruled against a Canadian program that required a majority of the solar panels and wind turbines that received a particular government incentive to be manufactured locally. And, in 2016, the WTO ruled against an Indian policy requiring a share of solar panels to be domestically manufactured. So far, India has defended its policies through the WTO, launching its own complaint against subsidies in the U.S. solar industry in several states, and appealed the decision of the original case.

Third, China again ran afoul of WTO rules in 2015 for its export quotas on rare earth elements. These elements were, until recently, almost entirely produced in China, and are important components of clean energy technologies—for example, the magnets in wind turbines. Beginning in 2010, China restricted exports of these elements, possibly to gain leverage on unrelated international diplomatic issues, raising world prices. Ostensibly in response to the WTO ruling, China has removed its export restrictions (Feketekuty 2000).

Looking ahead, more trade disputes seem likely. For example, to date, no formal dispute has yet arisen over Chinese policies that attract foreign equipment manufacturers—of wind turbine parts, for example—to invest in China with the requirement that they transfer technology to local partners. Coerced technology transfer is illegal under WTO rules, yet China's clear intention to build domestic expertise in producing clean energy technologies could easily run afoul of this ban (Lewis 2007).

5.6.2 Exports for All

The trade disputes to date may be just the beginning, foreshadowing all-out trade wars when clean energy products are as commonly traded and important to the global economy as oil is today. Assuming global clean energy demand continues to grow rapidly through mid-century as countries decarbonize their economies, the value of trade in clean energy will surpass that of any other class of goods. And it is plausible to envision a future in which countries would rationally choose to wage trade wars to secure the domestic benefits of producing and exporting clean energy products.

China has a formidable head start in cornering the global clean energy trade (see Fig. 5.3). The solar market alone, which China already dominates, is expected to grow by 13% annually (Fialka 2016). Chinese manufacturers also lead in wind turbine production and intend to export to emerging markets in North America, South America, and Africa (Clark 2016a) And in addition to producing much of the world's rare earth elements, China has bought lithium mines abroad to command all parts of the supply chain to make lithium-ion batteries for electric vehicles and grid storage (Sanderson 2016). The United States, by contrast, lags far behind China in clean energy manufacturing, and its endowment of natural resources useful to clean energy products is questionable (for example, it remains uneconomical to extract rare earth materials from U.S.-produced coal, despite hopes that this route might revitalize the coal industry and reduce dependence on Chinese rare earths; and ongoing efforts to mine lithium in Nevada, though promising, have not yet yielded substantial amounts of the material) (Rathi 2017; Tullis 2017).

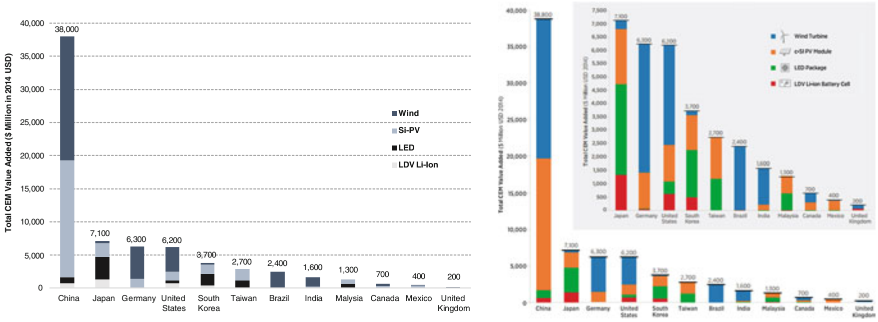

Fig. 5.3 Total clean energy manufacturing value added by country (2014). *Source* National Renewable Energy Laboratory

It is unlikely the rest of the world will accept a continuation of this state of affairs, in which China dominates a rapidly growing set of industries and monopolizes the enormous economic value they represent. Instead, countries are much more likely to view the transition toward clean energy as an opportunity to cash in on a global manufacturing boom for clean energy products. And as countries implement increasingly ambitious climate plans, they will be loath to bear the economic costs of an energy transition without reaping the benefits of increased exports and domestic job growth.

This could lead to a proliferation of protectionist policies, like domestic content requirements already deployed in Canada and India to give domestic producers a leg up over international competitors. And if China continues its habit of using public subsidies to boost domestic production, it could invite trade disputes and retaliatory action. International trade law is very clear, however, in its prohibition of discriminatory policies that favor domestic over international production.

5.6.3 Implications

This scenario sees the slow erosion of international trade rules in favor of ever-growing climate ambitions. Currently, it is rare for countries to flout WTO dispute settlement decisions. In 2050, non-compliance could become commonplace. Countries could instead protect their own domestic clean tech industries to boost economic output, reduce pollution, and increase energy security. While the WTO would still likely exist, it would lose its potency. Given the intricacy of international trade, noncompliance within trade in clean energy products could extend into other industries as non-energy products are dragged into wide-ranging bilateral spats. This could reprise the early 20th century when European countries hoarded industrial coal and steel.

The WTO's lengthy arbitration process may not be up to the task of mediating these disputes (Lincicome and Connon 2014). For example, it may take half a decade to resolve a dispute against China if it illegally dumps batteries for electric vehicles on global markets. At the conclusion of a lengthy WTO dispute resolution process, the United States might be allowed to enact retaliatory tariffs, but to no avail. Within several years, aggressive Chinese dumping would have had the desired effect. And this scenario might repeat, with other low-cost developing country producers following the playbook that China has already developed.

If the protectionist stances of the Trump administration endure, the United States is unlikely to defend the WTO and champion international trade rules. Instead the United States may join in, enacting tariffs on a wide swath of Chinese goods to protect its own manufacturers. The resulting world order might reflect the disarray prior to the WTO's formation. Trade around the world might devolve into smaller, bespoke patchworks of bilateral deals and a convoluted system of antagonistic tariffs.

To avoid a future where protectionism undermines global trade, the United States should lead by example, avoiding discriminatory policies that preference domestic industries in favor of international competitors. Free trade is the best way to minimize the cost of clean energy products, lowering the price tag of a clean energy transition in the United States. And the United States is better served by investing in domestic research, development, and demonstration of advanced clean energy technologies, rather than erecting trade barriers to prop up otherwise uncompetitive industries manufacturing less advanced products. The ideal future outcome for the United States and for most countries around the world is for America to develop innovative new clean energy products and for American companies to invest in supply chains around the world so that a range of countries enjoy benefits from the rise in the clean energy trade.

5.7 Clean Tech and Climate: A New Axis of International Cooperation

The preceding sections have laid out grim scenarios in which the rise of clean energy undermines free trade, empowers U.S. geopolitical adversaries like Russia, and prompts America to retrench militarily, economically, and diplomatically. But this is not inevitable. Rather, by asserting its leadership, the United States can ensure that the clean energy transition proceeds quickly enough to confront climate change and use the resulting diplomatic leverage to navigate an increasingly complex geopolitical landscape.

Thanks to its leading role in concluding the 2015 Paris Agreement on Climate Change, the United States earned goodwill internationally. In future decades, the United States can strengthen important geopolitical relationships—for example, in Asia and Europe—by continuing to lead global efforts to develop new clean energy technologies and combat climate change. By contrast, U.S. abdication of leadership on climate and clean energy—exemplified by President Trump's 2017 announcement that the United States will exit the Paris Agreement—will invite international opprobrium and make it more difficult for the United States to achieve its strategic aims.

5.7.1 Context

America's stance on climate change has spilled over into other areas of foreign policy. Early in his presidency, President George W. Bush withdrew the United States from the Kyoto Protocol, which set targets for industrialized countries to reduce emissions. Bush's rejection of the treaty prompted sharp rebuke from European counterparts who favored ambitious climate action. Because of the discord, it became more difficult for the United States and EU to cooperate on issues like joint military cooperation and global free trade.

Under the Obama administration, the United States stepped up its leadership on climate. American leadership was vital in creating consensus on the Paris Agreement between developed and developing countries. In addition to driving the formal UN process forward, the United States also spearheaded the creation of various fora to spur international cooperation. For example, the Clean Energy Ministerial continues to convene major economies to share best practices on the deployment of clean energy; many of the same countries are also members of Mission Innovation, a U.S.-driven initiative that has committed major economies to doubling their public energy R&D funding within five years. Most importantly, the Obama administration elevated climate to the top of its diplomatic agenda, requiring it to be raised at every single head-of-state meeting. And indeed, climate and clean energy issues soon came to dominate relations between America and the other two largest greenhouse gas emitters—China and India—both of which are geopolitically important countries to the United States.

With China, climate change has emerged as a rare area of genuine cooperation. In recent years, U.S. and Chinese officials have met regularly to discuss climate talks; jointly announced the U.S.-China climate pledge in 2014; and are actively collaborating on the U.S.-China Clean Energy Research Center (CERC) where Chinese and American researchers work side-by-side on clean energy research in areas such as clean coal and grid development (Innes-Ker et al. 2015). As a result, U.S.-China relations—which otherwise would have likely soured over disputes in the South China Sea, human rights violations, and cyber–espionage—remained constructive.

Similarly, cooperation on clean energy and climate change has boosted relations between India and the United States. Historically, India has kept the United States at arm's length owing to its diplomatic doctrine of nonalignment and disagreements over nonproliferation and trade. But, in 2009, the United States and India launched the Partnership to Advance Clean Energy (PACE), which focuses on solar energy,

energy efficiency in buildings, next-generation biofuels, and smart grids. Warm relations, to which cooperation on climate and clean energy have contributed, have in turn made it easier for the two countries to cooperate on increased trade and investment, defense, and, to a limited extent, nuclear nonproliferation (Council on Foreign Relations n.d.).

Although it is difficult to directly measure how U.S. climate and clean energy policy has influenced broader foreign policy, it is reasonable to say that American leadership on an issue that other countries deeply care about has eased diplomacy. Despite these benefits, it is likely that the United States will step back from leadership on climate change and clean energy under the Trump administration.

5.7.2 The Future of American Climate Leadership

Climate change will inevitably rise in priority on many countries' diplomatic agendas. Whether the United States embraces international climate action will likely have profound implications on its larger global agenda. The sections below provide two scenarios: one of a renewed American commitment to international climate talks and another of enduring withdrawal.

5.7.2.1 If America Steps Up

The benefits that the Obama administration enjoyed because of its climate and clean energy leadership suggest that President Trump's drawback from these issues may end up a historical aberration. It is plausible to imagine future administrations reverting to the much more prudent course of leading international climate negotiations and collaborations.

In such a scenario, by mid-century, the United States would have shepherded the world toward a series of compacts that had helped dramatically slash global greenhouse gas emissions. A well-functioning international institution would measure and verify each country's compliance with its emissions targets, and countries would regularly convene to set more ambitious goals for themselves, in accordance with the Paris Agreement. And the United States would have led a surge in financing from the richest countries in the world to support the mitigation and adaptation efforts of the poorest. Still, considerable work would remain, since the effects of climate change would have become increasingly pronounced, and net global emissions would need to drop below zero in the second half of the century to stabilize the world's climate.

Given this urgency, the world's nations would look to the United States as the undisputed leader of efforts to confront this crisis, affording it wide latitude in its international affairs. Such is the case with international approaches to address other tragedies of the global commons like nuclear proliferation and ocean resources extraction. The United States, because of its vast resources, enjoys broad fiat in setting global policies on these issues.

Moreover, in this scenario, the most important factor is the eventual mass commercialization of revolutionary clean energy technologies. Most of these would have been developed either domestically in the United States—which would have the world's most generously funded and advanced R&D facilities—or through the dense network of technology collaborations that the United States would have established with major economies around the world. As a result, American companies, having collaborated with Chinese or Indian or Brazilian counterparts, would have footholds to sell their jointly developed products into all of those markets.

5.7.2.2 If America Backs Down

If President Trump's stance endures beyond this administration, America could stand to lose immense diplomatic leverage. China has already demonstrated a willingness to pick up the mantle of leadership (Clark 2016b). In this scenario, by 2050, China would instead inherit many of the benefits detailed above by simply following up on earlier U.S. efforts.

In this future, China would lead a number of international institutions that will shape the global energy landscape. For example, China could steer the Clean Energy Ministerial and Mission Innovation to extend its commanding lead in clean energy industries.

Lastly, at the helm, China will be able to shape the finer details of the Paris Agreement that negotiators tabled for future discussions. In this future, China could push for less transparency in emissions reporting and tepidly improve its emissions targets. Such actions would reduce the world's chances of limiting climate change.

5.7.3 Implications

These scenarios hold disparate consequences for U.S. global influence. Especially as the effects of climate change become more pronounced into 2050, the United States cannot afford to abdicate leadership on a crucial diplomatic issue.

Stepping up would benefit both the United States and the world immensely, resembling the asymmetric costs and benefits of U.S. foreign aid. At present, U.S. foreign aid constitutes less than 1% of the federal budget but provides myriad benefits including preserving stability in strategically located countries like those in the Gulf, helping U.S. exports gain preferential market treatment, and providing a bargaining chip for negotiations (Rutsch 2015).

Even bigger prizes are possible from leading on climate and clean energy. The United States has already led the world toward a climate compact in which nearly every country made an independent commitment to curb rising emissions. And in disparate economic sectors, from electronics to pharmaceuticals, the United States has fostered world-beating, innovative industries. Doing so in energy will require hefty investments in domestic R&D and a network of partnerships with countries around the world, but the United States has already made considerable progress to date.

If, instead, the United States does not step up and cedes leadership to China and the European Union, it might squander a historic opportunity (Sivaram and Saha 2016). The United States would cede not only goodwill, but also diplomatic capital with strategic allies and the benefits of global trade. This chapter has taken pains to explain why the stakes are far too high to make such a mistake. Tectonic shifts are ahead for the global energy landscape—with reverberations that will echo in geopolitical arenas—and the United States stands to lose out if it shies away from leading in the 21st century.

5.8 Conclusion

It is difficult to know how the relationship between energy and U.S. strategic interests will evolve by 2050, but there are several good assumptions to make. The United States will continue to have geopolitical allies and adversaries spanning the entire globe. Energy, as has been the case for decades, will strongly shape those relationships. And clean energy and its attendant technologies will gradually displace fossil fuels in importance and use.

The sections above have introduced several geopolitically significant aspects of a clean energy future from a U.S. perspective. First, it may make military and economic sense to reduce its presence in the Middle East as fossil fuels wane in importance and U.S. exposure to oil markets dwindles. By 2050, the United States may withdraw from the Middle East and increase its presence in the Asia-Pacific. China and Russia will likely continue to be geopolitical rivals. The United States will lose crucial diplomatic leverage to both countries if it cannot compete in the next wave of energy technologies, particularly in nuclear power. The global norms America has built up over the last half century, like free trade, could crumble if countries embrace protectionism as clean energy industries rise in value. And the prospect of a sophisticated, internet-connected grid could expose the United States to threats from both state and non-state actors. It may seem that the disruptive influence of clean energy will subvert a postwar international order centered on the United States.

Still, new axes of international cooperation are on the horizon. An integrated grid could bind the United States, Canada, and Mexico closer together. And U.S. leadership on clean energy and climate could improve America's economic and diplomatic position even as geopolitical considerations shift. Cooperation on clean energy research and climate change has smoothed diplomacy between the United States and China. And India, a historically nonaligned country, has increased engagement with America because of its interest in these two issues. By adopting sensible policies, the United States could build on these diplomatic gains through the midcentury.

Although the United States is in many ways an exceptional player in international geopolitics, many of the U.S.-specific implications of a clean energy transition are consistent with the broader themes introduced in Chap. 1. That chapter laid out an overarching framework to understand the geopolitics of a future dominated by renewable energy. It predicted a shift away from a paradigm in which countries enjoy geopolitical influence in relation to their localized fossil-fuel deposits. Such a paradigm shift could affect America by reducing its security and economic interests in the Middle East and sparking a global competition—one possibly destructive to international trade norms—to become the energy suppliers of the future.

Another geopolitically significant theme that Chap. 1 introduced was increased electrification resulting from increased reliance on renewable electricity. Indeed, this is also relevant to the United States in two ways. First, as the United States relies more on electricity and increases its grid interconnections with its neighbors, the importance of regional energy relations will rise. And second, the risk of cyber-attacks from international adversaries could also grow as more Internet-connected devices touch the U.S. grid.

A clean energy transition may well have a disruptive effect globally. But the United States and the world will be best served if America continues to lead. To maintain geopolitical influence, the United States should invest in clean energy research in renewables, nuclear, grid, vehicle, and other technologies or cede leverage to great power rivals like China and Russia. Leadership on climate action and continued championing of global free trade will also advance U.S. and global interests.

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Chapter 6
The International Reverberations of Germany's Energiewende; Geoeconomics in the EU's Geo-Energy Space

Thomas Sattich

6.1 Introduction: Germany's Energiewende in Its European Context

Over the past decades, Germany has built a reputation for being a frontrunner in renewable energy. With the *Energiewende*[1]—the decision of the German government to base its national energy supply largely on renewables—German energy policy has become the focus of global observation (Hake et al. 2015, 532). Germany's potential to overcome economic and technological barriers to the growth of renewables by means of support measures and innovation are standing in the center of attention.[2] The effects of Germany's Energiewende, however, (increasingly) involve neighboring countries, with cross-border effects such as grid congestion or negative energy prices affecting their technological infrastructure and energy markets. This leads to a potentially explosive setting where it is not entirely clear who reaps the benefits and who bears the costs of the Energiewende. It also makes Germany's energy policy decision a European affair, and the success of the Energiewende co-dependent on the willingness of other European countries to

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[1] For the meaning of the word Energiewende, see also Sect. 6.4.1.

[2] A great deal of uncertainty actually remains about the prospects of renewables. It has to be noted that despite high growth rates in the renewable segment in Germany, renewables still account only for a relatively small fraction of the German energy mix. This is particularly true if their share in primary energy consumption (about 12% in 2016) instead of gross power generation (about 19% in 2016) is considered (Arbeitsgemeinschaft Energiebilanzen 2017, 8, 12). Given that the promotion of renewables yields high growth rates during their early phases, but soon reaches a point where adding new capacity encounters technological and economic barriers, this situation probably won't see a fundamental change in the near future.

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cooperate. The impact of Germany's Energiewende, therefore, has become a subject of under scrutiny.

To contribute to the discussion of the geopolitics of renewables in this volume, this chapter assesses the international reverberations of Germany's Energiewende. It investigates how Germany's policy to increase the share of renewables in its energy mix affects European energy politics in general and Germany's relations with other European countries in particular. Emphasis is hence placed on Germany's energy transition within its European context.

European energy politics is notoriously difficult to approach from a geopolitical angle. Of course, every EU Member (including Germany), as well as the EU as a whole, are integral parts of the global geopolitical landscape; but given the EU's legal and political framework, some fundamental elements of geopolitical reasoning simply do not apply when one focusses on politics within the European Union. For example, classical means of geopolitics, e.g. embargos and war, do not play a role in European politics. Moreover, the advanced state of European integration and the multi-level system of the EU make it difficult to separate the individual states from their European environment. Compared to other regions of the world, the separation between *national* and *inter-national* is, thus, much less clear cut. Nevertheless, political science today again underlines intergovernmental and bilateral dealings within the EU; moreover, in matters concerning energy, the EU is notoriously weak. In this field, the European Union can, hence, by and large, be seen as a system of states under a relatively thin supranational level of governance.

To study the inner-European effects of national energy projects such as the Energiewende, it is hence important to find the right theoretical angle. To this end, this chapter introduces the concept of *geoeconomics*. Two reasons are behind this approach. First, the lack of coherent EU policies leave the impression that European affairs are increasingly marked by a kind of power politics with soft means. Second, with its focus on economic power struggles, geoeconomics are capable of describing the relations between the EU Member States in fields where the EU shares competencies with the EU Member States, and thus structures intra-European affairs to some degree, but has not yet reached a degree of centralization high enough to fully overcome power politics between the European nations.

The chapter proceeds as follows: first, the concept of intra-European geoeconomics is introduced as an approach to studying politics in the European Union (Sect. 6.2). Second, the EU's *geo-energy space* is discussed, that is a theoretical concept for understanding the entanglement of economic and societal energy systems the German Energiewende is located in and corresponding with (Sect. 6.3). Finally, the implementation of the Energiewende in Germany (Sect. 6.4.1), as well as its technical and political implications are studied (Sect. 6.4.2) and discussed in detail (Sect. 6.5), before some conclusions are drawn (Sect. 6.6).

6.2 Intra-European Geoeconomics

The perspective of political science on the inner workings of the European Union has seen a remarkable change in the course of the past decade: During the post-millennium years, EU studies have been dominated by neofunctionalist 'governance' research, which takes the existence of a 'Europolity' (Jachtenfuchs 2001, 250) as a given, and assumes that the European Community has developed 'the competence to make binding rules in any given policy domain' (Sandholtz and Stone Sweet 1997, 297). Yet despite some degree of centralization on the European level, the national grip on various policy areas (Krotz 2009, 557) remained a significant obstacle for the pooling of the EU's ample resources behind common policies (Leonard 2016, 26), and since the beginning of the European sovereign debt crisis, the reluctance of the EU Member States to transfer power to traditional supranational bodies has increased again (Bickerton et al. 2015, 704). Consequently, EU studies today again underline the intergovernmental nature of EU politics. Furthermore, a Europe-wide trend of bilateralism has been identified (Kausch 2011, 47; Krotz and Schild 2013, 1), with the EU Member States engaging in bilateral deals (Prislan and Torreblanca 2011, 53; Kausch 2011, 47; Krotz and Schild 2013, 1) instead of fixing their problems collectively. It is, therefore, again questionable to what extent the EU can be described as a unitary policy actor (Krotz 2009) distinguishable from its component Member States. Put differently, the EU still represents an 'unusual hybrid' (Collard-Wexler 2006, 427) between centralized governance on the European level and *classical* bilateral relations between the Member States, with the latter having gained importance during the past years.

Energy policy represents a good example to illustrate this state of affairs. In this field, the EU developed a certain degree of centralization of decision-making power; moreover, a comprehensive European legal framework has been developed around the three principal aims of energy security, competitiveness, and sustainability. The extent to which this framework is capable of gearing the EU Member States towards these aims is, however, the subject of scientific dispute (see e.g. Helm 2014). In contrast, the perspective, that energy is a field where the Member States have a particularly wide leeway for pursuing their own agendas, is widely accepted.[3] Moreover, energy plays a crucial role for economic prosperity and the security of a given country, the protection of its infrastructure, industry, and markets etc.; it thus remains a strategic question for the individual EU Member States—be there an EU policy framework or not. Hence, when it comes to energy, the focus of the European political system remains on the national level.

To study the impact of Germany's Energiewende on the relations between EU Member states, this chapter draws on the concept of geoeconomics. This school is not to be found among the classical theories of EU studies but rose to prominence in the 1990s as a counterweight to the classical geopolitical thinking (Khanna 2012, 3).

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[3] Article 194, 2 of the Lisbon Treaty (TFEU) defines, for example, relatively narrow barriers for stronger centralization of energy policy on the EU level.

Based on the neorealist tradition, geoeconomics expect 'the ancient rivalry between nations' (Luttwak 1993, 34) to continue, and focus on shifts in the power structure between nations. However, in contrast to other branches of neorealist IR theory this school stresses that 'much of politics is actually economics, and most of economics is also politics' (Lindblom 1977, 8), and thus highlights the importance of markets as the primary driver of a nation's foreign policy choices (Blackwill and Harris 2016, 37). Moreover, 'new industrial means' are expected to be the instrument of choice in international power struggles (Luttwak 1993, 34). Put another way, geoeconomics sees politics and economics to be the two sides of the same coin, with economic forces being an important driver as well as an instrument of politics and vice versa (Luttwak 1990; Carr 1961, 114 et seq.); further, geoeconomics expect states to leverage political power over other countries mostly (but not solely) via economic linkages (Holsti 1976, 293). In other words, geoeconomics emphasize the *economic* balance of power and the *grammar of commerce* between nations (Luttwak 1990) and assume that the structural features of markets more than ever determine the effectiveness and capacity of states to influence the international system in their favour. Thus, in contrast to geopolitics, geoeconomics see the concept of power not primarily related to the control over territory (e.g. Jönsson et al. 2000, 20), but the control over a given *geo-economic* space (Cowen and Smith 2009, 38), with GDP, trade balances, currency reserves, and foreign investment being some of the factors under scrutiny when power structures between nations are being assessed (Khanna 2012, 3).

The Member States of the European Union do not have fundamentally different core goals and policy preferences than non-EU members (Moravcsik 1993), and just like other states, they take external actions to achieve them (Reynolds 1994, 54). Furthermore, EU Member States have continuously shown their unwillingness to make concessions during intergovernmental negotiations (Naurin 2015); it follows, that the bilateral relations between European countries do not remain without conflict. Hence, it can be assumed that the balance of power is still relevant for the EU Member States and their foreign-policy calculations vis-à-vis other MSs (Rosato 2011). However, from the point of view of geoeconomics it is concepts such as welfare, status, and prestige that drive the relations between the EU Member States, and not primarily security and autonomy (Holsti 1995). Moreover, given the strategic importance of sectors such as energy and industry on the one hand, and their growing inclination to engage in bilateral deals, the EU Member States are likely to circumvent the leeway which the European Union formally or informally imposes on them and their actions—at least in cases where they deem such a course of action necessary and tenable.

Therefore, it has to be assumed that on the field of energy the EU Member States pursue agendas more or less independently from the EU framework and use whatever policy instruments they deem feasible (Rosato 2011, 73) when dealing with each other. Several options are available to them: (i) exploiting legal grey areas; (ii) using instruments which are either not covered by the EU's legal framework, or *soft* enough to be applicable; (iii) ignoring the EU altogether. Hence, while EU Membership implies limitations with regard to the foreign policy options and the range of policy tools available to EU Members, individual countries have a broad range of possible courses of action to pursue and enforce their national interests, particularly if (soft) economic means are taken into account. This does, however, not mean that the EU had abandoned rules-based multilateralism. In very broad-brush terms, the EU is suspended somewhere in between enthusiastic reliance on liberal interdependence and zero-sum survival mode' (Youngs 2011, 16).

6.3 The EU's Geo-Energy Space

To explore the European reverberations of Germany's Energiewende within European energy politics from a geoeconomic perspective, technical, economic, as well as political factors need to be taken into account. The notion, that the societal function of energy (Verbong and Loorbach 2012, 9) is the product of *socio-technological energy systems*, represents a good starting point for this undertaking. Consisting of large technological systems (Mayntz and Hughes 1988) and the private and/or public systems[4] that build, operate and govern their diffusion and use (Unruh 2000, 825–826), these systems evolve embedded in a wider *environment*; the topography of this environment is defined by the geographical position of the land, climate and available resources, as well as softer features such as political constellations, economic cycles and broad societal trends (Verbong and Loorbach 2012, 9). The European level of this environment is only weakly developed due to (a) the fractured geography of Europe (which makes interconnection difficult to achieve technically and/or economically), and (b) the fact that for decades, energy companies and states were strongly orientated towards the national level as the most promising in terms of markets, financing and regulation (Van der Vleuten and Högselius 2012, 81).

In this semi-enclosed national context, a *commingled relationship* of (Abdelal 2011, 426), or *opaque intertwinement* (Pointvogl 2009, 5705) between energy companies and the state emerged. Consequently, energy is a field where the efforts to develop a degree of centralization encounter relatively strong difficulties (Lagendijk 2008). However, energy is also a field where self-sufficiency is not always the most favourable option. Historically, the development of energy systems in Europe was therefore accompanied by initiatives to increase the level of cross-border integration (Schipper and Van der Vleuten 2008, 6). Moreover, a number of institutions on the European level emerged for the purpose of coordinating the development of technical energy systems (Lagendijk 2008), even before the European Union increased its activity in this field in the early 1990s. Together, these initiatives resulted in some degree of integration of energy systems, the development of transnational power pools (Lagendijk and Van der Vleuten 2013,

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[4] Here, the term 'systems' encompasses a wider number of concepts such as *organizations*, *institutions*, and *interactions* (Joerges 1988, 19).

76), and, with the EU gaining competencies in the field of energy, a level of governance on the EU-level. Yet the powers of the EU remain limited, and its governance structures could not bring the various energy policy positions of EU Member States into full alignment (Bössner 2015).

The result is what can be labelled the *EU's geo-energy space*[5] (Manñé-Estrada 2006), a heterogeneous and multi-level (Smith et al. 2010) entanglement of energy systems across Europe under a thin governance structure. In this space, the various national systems interact closely and regularly, with a precise set of energy relationships taking place between the historically grown socio-technical systems on the national level (Manñé-Estrada 2006, 3781). Change in one national energy system, therefore, affects the *energy metrics* of the wider area and the relative position of others in it (Coccia 2010), with implications for (1) supply lines (Sattich 2016), (2) generation units (Brunix et al. 2013), (3) power transmission and distribution (Singh et al. 2016), and (4) electricity markets in neighboring countries (Roques 2014). The level of interconnection within this structure varies, however. On the one hand, cases such as the Austrian-Swiss (Ibid., 80) or the Dutch-German (Frontier Economics 2015) ones represent examples for a transnational approach to the coordinated development of power systems. Here, changes on the national level strongly affect energy systems across the political border. In other cases, markets, ownership and control structures still overlap strongly with individual states (or sub-national governmental levels); in these cases, the exchange between national systems remains at minor levels and (sub-) national power circulation clearly dominant (Lagendijk and Van der Vleuten 2013, 80–81; ENTSO-E 2016, 17); where this is the case, the cross-national effects of national energy projects remain rather indirect.

The topography of the EU's geo-energy space hence remains in a *semi-integrated/semi-fractured* state which combines well-integrated parts with areas which remain separated by several main and secondary boundaries in the energy transmission infrastructure (ENTSO-E 2016, 17) and the different technical, political, legal, economic, and natural legacies of individual countries. Any policy that affects the structure of this space, be it national or European, will thus have to overcome resistance to change, even though the strength of this effect varies greatly across Europe. The topography of the EU's geo-energy space hence influences the evolutionary pathways of today's power systems (Verbong and Geels 2012) and, thus, the likeliness of meeting the ambitions behind existing European policies and new encompassing projects such as the Energy Union (European Commission 2015) or the 2030 targets (European Commission 2014a).

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[5] In contrast to Manñé-Estrada's concept of a pan-European space, this chapter focusses on the territory of the European Union, understood as the sum of the energy systems on the territory of EU Member States without their overseas territories.

6.4 Germany's Energiewende: National Implementation and International Reverberations

The (semi-) integrated nature of the EU's geo-energy space, and Germany's central location within it, implies that German energy policy choices reverberate through neighboring systems. A successful continuation of the Energiewende, therefore, involves technological and economic adaptations beyond Germany's borders. Not every party will benefit equally from these changes. It can be assumed that some parties will attempt to avoid the changes necessary for implementing the Energiewende—either by remaining indifferent vis-à-vis German initiatives, or, where they have a strong enough (legal, economic, technical and/or political) lever, by actively influencing the evolution of Germany's energy sector. Germany, on the other hand, can be assumed of being engaged in actions to influence the evolution of the European energy system according to the requirements of its Energiewende policy. Hence, the question arises what the implications for the EU energy space in general and for Germanys' energy relations in particular will be; what new challenges and opportunities can we observe? Moreover, considering the EU-framework mitigates direct power struggles between individual Member countries, though it cannot entirely prevent bilateral struggles of a geoeconomic kind, how will changes manifest themselves? To study the geoeconomic implications of the Energiewende, we first established what it actually is by reflecting on its origins, aims, and implementation (Sect. 6.4.1). Subsequently, Sect. 6.4.2 analyses the reverberations of the Energiewende through the EU's geo-energy space.

6.4.1 The Political Economy of Germany's Energiewende

Germany's *Energiewende*, a policy to overhaul the country's energy infrastructure from a system based on nuclear and fossil fuels to one centred on renewables, has deep historical roots. It dates back to the end of the Renewable Energy Act of the year 2000 (EEG), which again can be traced back to the Act on the Supply of Electricity from Renewable Energy Sources of 1991 (StrEG). Implementing both acts has been motivated by the Chernobyl nuclear disaster in 1986, which until today affects some parts of Germany (particularly Bavaria where the 1991 Act has originally been conceived; Die Zeit 2006). Another stimulus for Germany's move towards renewables is the anti-war movement of the 1970s and 80 s, which can be traced back to the worst of times of German history (Hake et al. 2015, 534–535). And if one goes even further back in time, a romantic fascination with nature can be discovered in German culture, and, thus, a great interest of the German public first in nature conservation and later environmental protection.

German culture may also explain the comparably strong reaction of the German public in the face of the Fukushima nuclear disaster in 2011. In turn, the very negative feelings of the German public towards the events in Japan stimulated the *reciprocal manipulation* (Luttwak 1990, 129) between the renewable energy industry and political authorities in Germany. Stated in another way, German energy policy has been influenced by a diverse advocacy coalition of renewable energy supporters such as environmental interest groups, industry associations, research institutes and agencies (Bosman 2012) already before 2011 (see BMWi 2010), but when faced with the Fukushima disaster, this coalition accomplished to turn around German energy policy.

This *energy revolution*[6] (as the German Chancellor Angela Merkel put it) or *Energiewende*[7] aims at restructuring the whole of the German energy sector. To reach this aim, a set of intermediate targets for emission reduction, efficiency increase and the electricity, transportation and household sector has been defined (Knaut et al. 2016, 477–478). Primarily, this policy concerns the electricity industry: Nuclear energy is to be phased out by the year 2022, while the share of electricity generated by renewables (solar, wind and others) in gross electricity consumption is to be increased to at least 35% by 2020, 50% by 2030, and 80% by 2050. With these and other measures (e.g. increased energy efficiency, for example in the heating system), it is hoped to reduce Germany's energy consumption by 50%, and greenhouse gas emissions by 80 to 95% until the year 2050 (BMWi 2015, 7). The use of fossil to be decreased accordingly.

Defining and implementing these aims contradicts earlier energy policies: Shortly before the Energiewende decision, the German electricity sector has seen two very different turnarounds, yet in the opposite direction: Just nine months prior to Fukushima and the Energiewende decision that followed it, the previously existing nuclear phase-out policy had been circumvented by prolonging the statutory life time of nuclear plants. Moreover, new investments in coal fired power plant amounting to 11.3 GW or around 15% of the total sector capacity were brought on the way (Pahle 2010); as investments in the energy sector are long-term, this German *dash for coal* now resulted in stranded assets for the incumbents in the electricity industry, not to mention the nuclear plants the dismantling of which they now have to finance (FAZ 2017). In a sense, the Energiewende, thus, goes directly against the conventional wisdom that energy policy is made by big utilities. What is more, its implementation went directly against substantial opposition from well-organized groups in the conventional electricity sector (Strunz et al. 2016).

Again, the problems of big, fossil-nuclear interests now are facing has to be seen as the result of a longer historical process. In the 1990s, the position of the big utilities was still very much undisputed; accordingly, their interpretation of the 1991 StrEG was such, that no bigger impact of renewables on the structure of electricity supply was expected. However, in the following two decades, the continuous growth of renewables slowly eroded the position of fossil-nuclear based utilities (Strunz et al. 2016). As a result of this process, the renewable energy industry today does no longer represent a niche but has slowly become a central element of the

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[6] From the Latin 'revolutio', a 'turn around'.

[7] From the German 'Wende', a 'turn'.

German energy regime (Sühlsen and Hisschemöller 2014, 324). As a consequence, the transition to sustainability also has an impact that goes way beyond the electricity sector, as new demand for equipment, its deployment and maintenance is now driving parts of the German economy.

For example, energy-intensive industrial companies that purchase electricity on the wholesale market now enjoy a windfall in low energy costs resulting from (surplus) electricity at certain peak hours (see Sect. 4.2; Cunningham 2017). Moreover, manufacturing is profiting from the strong demand for wind turbines, with German companies like Enercon (onshore) and Siemens (offshore) holding the lion's share of Germany's wind power generation units and a very strong position in the global market for this sort of equipment (Wind Monitor 2017). Beyond, the Energiewende plans involve many other industries such as the auto industry through support for e-cars. Even agriculture is included by the support for the use of biofuels. Beyond the support for renewables, energy efficiency is probably the most important issue regarding the economic impact of the Energiewende, as the fuel cost savings and investments may translate into benefits for the building sector, data processing, electronic and optical products as well as chemical and pharmaceutical manufacturers; combined, these effects may activate GDP growth in the range between 0.4% (average additional annual growth of 0.008%) to 2.6% (average additional annual growth of 0.52%) for the German economy, thereby contributing to sustained domestic demand as well as enhanced export opportunities (Ringel et al. 2016, 1298).

All in all, Germany's comparative advantages is a frequently mentioned subject in scientific literature as well as energy-related public discourse in Germany. Hence, the country's pioneering role and heavy investments in the renewable energy industry are widely seen as a strategic move to create a leading position for German industry in the mentioned areas. For example, measures taken to boost innovative capabilities and creating future growth markets for renewables (Pegels and Lütkenhorst 2014, 522) have been interpreted as a strategy to benefit German business and to defend the country's role as a leading manufacturer (Kausch 2011, 47). In view of these issues, the proponents of the Energiewende frequently interpret the economic adjustments implicit to the transition towards sustainability as a national project of green industrial policy of the first order (Pegels and Lütkenhorst, 2014, 532).

So far, the Energiewende policy has, however, been only partly successful in reaping the benefits of restructuring the German economy. For example, the attempts to establish an industry for the production of solar panels has failed due to competition from China. Moreover, the Energiewende demands increasing surcharge on electricity tariffs to support the development of renewables, thereby eroding the competitiveness of Germany's export orientated manufacturing base. So as to maintain those firms' competitiveness on global markets, energy-intensive industries had to be exempted from paying those levies (Knaut et al. 2016, 487). Moreover, the Energiewende policy may come at the expense of large utilities which now are forced to write off some of their most profitable assets, as well as smaller energy users that don't qualify for exemptions from growing surcharge on electricity and therefore suffer from growing energy prices.

6.4.2 The Interactions of Germany's Energiewende with Neighboring Energy Systems

Given the deep historical roots of the Energiewende, and the fact that the plans to transform the country's energy sector have been elaborated already before the Fukushima nuclear disaster in 2010, the decision taken by the German government to complete the turnaround of Germany's energy policy did not come as a total surprise (see Sect. 4.1). However, Germany took this decision without much regard for the impacts on its neighbors. The initial indifference of the German government towards the consequences of its policies for energy systems in neighboring countries is a good example in this regard (see below; Helm 2014, 33). Despite its own self-perception as a frontrunner of Europeanization, Germany does, apparently, not always follow the code of conduct implicit to EU Membership and/or the spirit of EU law. On the European level, the reactions to German energy policy are, therefore, not in every case friendly.

The StrEG from 1990 has, for instance, been received with scepticism by the then EU Competition Commissioner Karel van Miert. In his opinion, the law represented an illegal subsidy for German energy companies, a reproach the European Court of Justice finally annulled in 2001 (Die Zeit 2006). Later, the European Commission opened an in-depth investigation to examine whether the support for renewable energy and the surcharge reductions granted to energy-intensive companies under the EEG law gave those companies an undue economic advantage over their European competitors. The Commission confirmed that the support for renewable energy production and the surcharge reductions for energy-intensive companies is in line with European guidelines; however, the Commission also concluded that the actual reductions granted to some energy-intensive users exceeded the levels set, and thus gave the beneficiary companies an undue advantage over their European competitors. To compensate for this, the companies had to pay back the reduction; moreover, Germany had to commit itself to invest 50 million EUR in cross-border interconnectors and other European energy projects, so as to remedy any risk that the measure discriminated against imported electricity (European Commission 2014b).

The latter represents an interesting point, as it confirms, that major national energy projects such as the Energiewende have to be studied against the backdrop of their particular regional context (Bridge et al. 2013, 333). Seen from this perspective, the restructuring of energy systems is embedded in a particular setting of connections, dependencies and control; this is most obvious with energy infrastructure, particularly electricity distribution grids, but can also be extended to the geopolitical and geoeconomic dependencies associated with the multinational

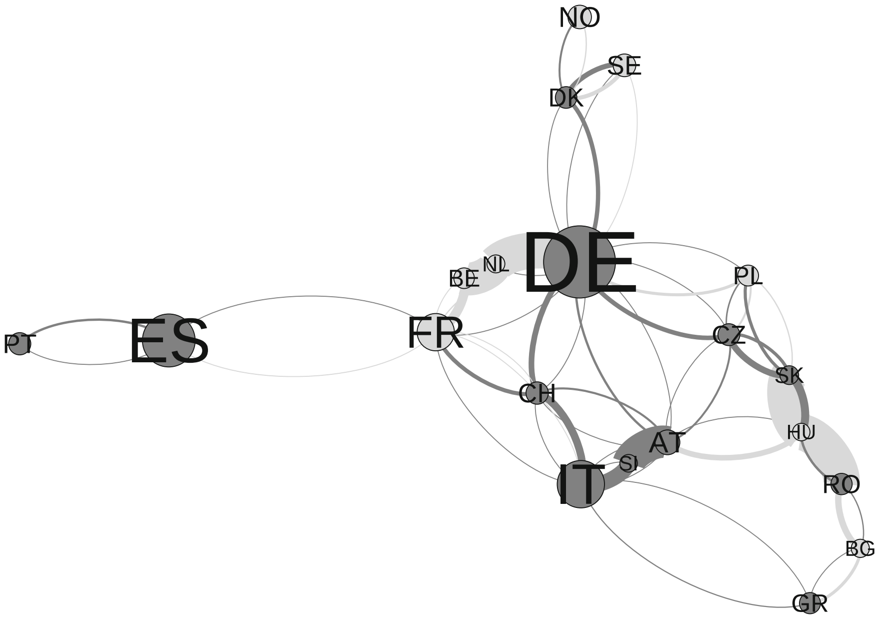

Fig. 6.1 Net transfer and surplus capacities in the EU's geo-energy space (winter 2009/2010). *Notes* node size indicates surplus (dark grey) and lack of (light grey) generation capacity; edges indicate the capacity for balancing surplus/lack of capacity by export (dark grey) or import of electricity (light grey); distances between nodes indicate the level of integration between two systems. Sources: monthly peak demand (hourly load values, ENTSO-E, n.d.a); Net Transfer Capacity (winter 2009/2010, ENTSO-E, n.d.b); surplus generation capacity (2010, Eurelectric Eurelectric 2012)

ownership of oil, gas and electricity companies (Ibid.). Hence, the fact, that a dozen or so national energy systems are linked to the German one (see Gailing and Röhring 2016; Hamhaber 2015, 636) will complicate the process of implementing the Energiewende—particularly as each national system has unique features and thus corresponds differently with changes in Germany. In this context, the size of the German economy, as well as its status as Europe's largest consumer of energy, also need to be taken into account, as they give Germany an elevated position in the EU's geo-energy space (see Fig. 6.1). Moreover, in view of the country's role as Europe's biggest producer and exporter of manufactured goods, a major project of green industrial policy such as the Energiewende can be expected to have direct consequences for industries in neighboring countries. Lastly, indirect links between Germany's energy policies and, for example, businesses in other European countries have to be taken into account if the reverberations of the Energiewende are to be conceived.

In other words, restructuring the system of supply and demand of energy in Germany (Knaut et al. 2016, 486) has direct as well as indirect technological and economic reverberations across Europe (Schreurs 2016; Moss and Gailing 2016), and not every party embraces the consequences.[8] In turn, these geoeconomic reverberations may represent or cause (new) obstacles for the attempts to transform the German energy system.

In this context, the changing geographical distribution of power generation capacity across Germany is an important aspect. The most prominent issue in this context is the deployment of great numbers of wind power generation units far away from the densely populated and industrial parts of Germany. Taking offshore wind parks in the North Sea as an example, an additional electricity generation capacity of more than 4 GW of capacity has already been realized between 2010 and 2016, and more than 6 GW are either in construction or authorized (Wind Monitor 2017). Moreover, the installed capacity of onshore wind power in the northernmost German Länder (Lower Saxony, Bremen, Hamburg, Schleswig-Holstein, Mecklenburg-Vorpommern) already amounts to about 20 GW (Wind Monitor 2017). Hence, with a total of 197.25 GW in Germany in 2016, wind power in the country's north already amounts to more than 12% of German net installed electricity generation capacity (Fraunhofer ISE 2017) and is about to rise further.

In view of the envisaged magnitude of the Energiewende and the centrality of the German power system in Europe, this development is very likely to have an impact on the load factor and the level of congestion of cross-border interconnectors with neighboring countries (Schroeder et al. 2013). Considering, for example, that the biggest consumption centre in Germany's northernmost region, Hamburg, has a maximum load factor of about 1.9 GW (Energieportal Hamburg 2017), further increasing wind power capacity in the area will create considerable oversupply of electricity in Northern Germany (especially at peak hours, see below)—hundreds of kilometers away from the country's consumption centres in the densely populated and industrial areas in Western and Southern Germany. The Energiewende, thus, requires significant changes to Germany's electricity transmission grid. However, given that the electricity transmission infrastructure is international in its design, the developing oversupply of wind-generated electricity in Northern Germany will also affect the regional energy mix in Germany's northern vicinity. In turn, this change in supply (will) require(s) adaptations of the electricity transmission and distribution infrastructure on the territory of Germany's neighbors, a fact which is not necessarily received positively. Where the effects are such that they entail significant costs, conflicts can be expected between the various parties. For example, the reception of the new transmission capacity between Germany and Norway has met with mixed feelings on the Norwegian side, for example by nature conservationists (Gullberg et al. 2014).

Hence, the looming concentration of wind power is causing frictions between Germany and its neighbors. However, the future strength of these effects will vary

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[8] The Polish weekly news magazine 'Najwyższy Czas!' ('High Times!') Nr. 36-37, 2017, for example, headed 'the Nazi roots of renewable energy'. According to the author, it is "impossible not to get the impression that the ideology of ecology born in Nazi Germany triumphs again"—to the detriment of the Polish coal industry.

depending on the extensions of north-south grids in Germany (Schroeder et al. 2013) and future technological choices. For example, solar power installations are already significant in both numbers and their impact on cross-border electricity transmissions; but despite their geographical concentration in southern Germany, particularly Bavaria, the individual solar generation units are rather dispersed locally and connected mostly to the (subnational) power distribution grid. Compared to the international impact of wind power, the oversupply of solar generated electricity is, hence, less significant, and mostly concerns the energy system of Austria (Singh et al. 2016, 296) which is already closely integrated with the German one (see below). However, assuming that the numbers of solar power will continue to rise, these effects can be assumed to become more significant and also more frequent in the future, and therefore also more problematic. Biomass, on the other hand, can be used for electricity generation either locally or transported to and used in the existing centralized power plants (e.g. by co-firing biomass together with coal); compared to wind power and solar power the impact of this form of energy would, hence, be less significant for the geography of the German energy system. Today's numbers of biomass are, however, negligible, and it remains to be seen what share this form of renewables will have in the future. Finally, given the historically strong position of coal in the German energy system, Germany might still opt to give the Carbon Capture and Storage technology (CCS) a role in the portfolio of measures to reach decarbonisation of the energy sector (Praetorius and von Stechow 2011). Except for technological leadership in this field, the impact on the established energy relations with the country's neighbors resulting from such a policy would probably be minimal.

Beyond the geographical allocation of electricity generation in Germany, the intermittency of electricity generation from wind and solar energy also represent a factor of the international reverberations of Germany's Energiewende. According to the European Commission, existing power systems are flexible enough to counterbalance 5% of intermittent renewables (European Commission 2012, 8; see also IEA 2011). Where this margin is exceeded, measures need to be taken to absorb network fluctuations. With an annual net generation of 514,731 GWh of electricity in 2015 (Eurostat, n.d.) on a total of national territory of 357,168 km^2, and a share of intermittent renewables of 269,3 MWh/km^2 (ECN, 2011, 124, 132, 142), intermittent renewables already accounted for about 18% of electricity generation/km^2 in Germany. Notwithstanding regional variations, the German energy system has, thus, become relatively volatile, and the share of wind, solar and tidal power is about to grow further (see Fig. 6.2). So as to enable the envisaged near-to-complete switch to renewables, Germany's Energiewende will, therefore, increasingly require measures to increase the flexibility of existing power systems. Closing the gaps in the cross-border transmission infrastructure are seen as a possibility in this regard (ENTSO-E 2016). However, where the capacity of cross-border interconnectors between Germany and its neighbors is to be increased, the latter might be forced to increase their balancing power in order to cope with the supply fluctuations caused by wind and solar generation in Germany.

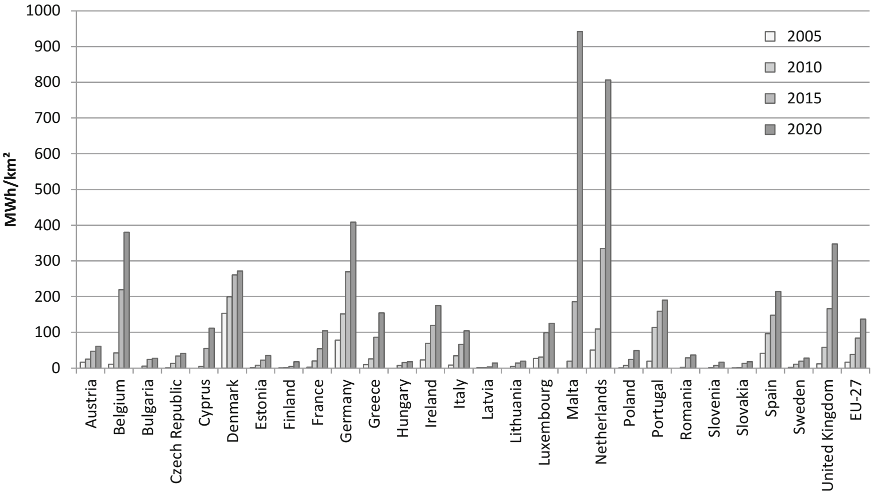

Fig. 6.2 Calculated per area generation of intermittent electricity (wind, solar, tidal) (MWh/km^2). *Source* ECN (2011, 124, 132, 142)

To compensate for surges in demand at times of low wind and solar energy, German energy industry had, for example, to rent reserve plants in Austria to supply its consumers in Southern Germany (Handelsblatt 2016). On the other hand, at times when wind and solar installations are working near their maximum capacity, electricity is pushed into neighboring countries, particularly Poland, the Czech Republic, and the Netherlands, thereby straining power lines, interconnectors, as well as plants that were designed to run at constant rates (Singh et al. 2016). Technically, a transition to gas fired plants would help the affected countries to deal with these fluctuations; however, tackling cheap wind power from Germany with expensive gas fired plants does not appear to be an economical course of action; moreover, new gas fired plants that would thwart Poland's ambition to decrease reliance on gas supply from Russia. The loop flows of electricity, therefore, should be solved on the bilateral or regional level (Agora Energiewende 2015, 48–49); but as the commission of phase shift transformers at the Polish-German border shows (50Hertz 2016), the countries affected by them tend to resort to a kind of defensive realpolitik rather than embracing a transnational approach to the development of energy systems (Agora Energiewende 2015, 41). Once completed, these phase shifters will be able to close off the Polish and Czech system at certain times, and thus run against the goal of a common European market for electricity. Such a development moves electricity grid interconnection further away from, rather than towards, the ever-closer grid communities as expected by Scholten and Bosman (2016).

Beyond these rather technical issues, energy markets in neighboring countries are also affected by the changes following the Energiewende (Auverlot et al. 2014, 23). Realignment of market zones is one measurable effect (Umpfenbach 2017).

Fig. 6.3 Germany's position in the EU's geo-energy space—share of German electricity in neighboring systems. *Sources* Final electricity consumption (Eurostat, n.d.; ENTSO-E, n.d.a) and electricity exports (Eurostat, n.d.) 1990–1999, 2000–2009, 2010–2015

For instance, wind power from Germany was, for example, found to be negatively associated with spot prices in other markets (de Menezes and Houllier 2015, 365). With the drawback of growing volatility in the transmission system, electricity generated in Germany is, therefore, gaining market shares across Europe. One example in this regard is the Netherlands, where its share increased strongly over the past years, and today already accounts for 20% of electricity consumption (see Fig. 6.3).

As in the case of infrastructure, the reaction to this development is mixed. On the one hand, the growing exports of German wind and solar energy represent a welcome development for some actors outside Germany. Embracing the economic possibilities of the German energy transition, Norway's Foreign Minister has, for example, announced that his country would be happy to become a 'green battery for Europe' (Schlandt 2015). Another example is the case of Austrian energy industry, which has profited greatly from using cheap electricity from Germany to fill their pumped hydro plants; moreover, Austrian energy-intensive industry has profited from electricity trade between the two countries. However, Germany's threat to unilaterally end the common power price zone with Austria is a stark indicator that this issue is seen rather negatively by German policy makers (Handelsblatt 2016; Benz 2016). Moreover, the oversupply of relatively cheap wind power from Germany also causes electricity generation in neighboring countries to operate at limited capacity, with the affected industries responding negatively. Finally, costs for necessary infrastructure adaptations in reaction to changing markets also represent a factor, as shown by the energy intensive industry in Norway who does fear that more electricity cooperation with Germany will raise electricity prices (Gullberg et al. 2014).

6.5 Discussion

The European Union is a rather specific political context to study the *geopolitics of renewables*, because what the EU essentially represents is an attempt to overcome geopolitical struggles in Europe! And given the normality of EU-level politics today, this project can, despite all flaws, be considered a success. Hence, at first sight, the attempt to discuss the European politics of renewable energy from a geopolitical perspective may appear an odd undertaking. However, neither is the EU a state, nor without internal conflict, and the past years have made it apparent that the fractures between the EU Member States are deeper, and the frictions between them stronger than has been assumed for years; and not in all cases the policies of individual Member States are oriented towards European solutions. In other words, Community politics today appear more frayed than ever. Negotiations in Brussels may often prevent bilateral dealings, but neither has the rivalry between the Member States disappeared, nor have EU politics fully replaced bilateral politics in Europe. Hence, not in all cases the rivalries between European countries remain hidden under the carpet of the institutionalized bargaining processes on the EU-level.

Germany's historic turn towards renewables in 2011, is a major event in this context. Essentially a plan to increase the level of sustainability of Germany's economy by massively expanding the share of renewables, this policy can also be interpreted as a major example of a green industrial policy. Indeed, the relations between national energy policy and the renewables industry are tight, and it is no secret that future economic success on fields such as manufacturing is one of the motivating factors behind the Energiewende. Moreover, the Energiewende does not function isolated from surrounding energy systems; as a matter of fact, the Energiewende represents a dynamic element which shakes the EU's geo-energy space, and it will do so with increasing strength, depending on the future economic and technological choices in Germany. Hence, Germany's efforts to base its energy supply largely on renewables has implications for market areas and energy infrastructure beyond the German borders, and not every party in neighboring countries benefits (equally) from these economic changes or will do so in the future.

Given that a successful implementation of the Energiewende depends on smooth interactions with the wider environment, the European context now plays a central role in the discussions around German energy policy. A major issue in this regard is the lack of power transmission infrastructure to bring wind power produced in Northern Germany to the manufacturing industries in the country's west and south. Today, without the transmission infrastructure in Germany being sufficiently developed to support the growing numbers of renewables, temporary grid congestions extend to the country's neighbors, where they continuously increase the need for infrastructure adjustments. The changing allocation of electricity generation capacity in Germany, the growing volatility of the power grid, and falling wholesale prices on the electricity spot markets have been shown to represent other major issues in this context.

But the political implications of all these effects vary, depending on the specific mix of interests involved in a given case. For example, the Energiewende affects the international relations between Germany and its neighbors differently in the north and the south. Germany's transition towards low-carbon solutions clearly has the potential to result in both more cooperation and more conflict in Europe. Coordinated efforts such as the planning of international offshore wind parks (Klip 2015, 25) and grid projects such as the North Sea Countries' Offshore Grid Initiative (Fraunhofer IWES 2013, 33) indicate the potential of cross-national energy policy. However, issues such as the deployment of phase-shifters and Germany's threat to break up the common price zone with Austria also indicate the possibility that the Energiewende is driving a development leading to its increasing isolation and hence a greater fragmentation of the EU's geo-energy space.

6.6 Conclusion

Energy systems in the European Union have merged into a semi-integrated structure. Therefore, any major economic or technological change in one of the national components of this geo-energy space affects one or several or even all the others. Moreover, given the close proximity between the energy industry and governments, as well as the societal importance of the subject of energy, any arising issue has a political component and therefore tends to affect the political relations between European countries. That said, the international reverberations of national projects to increase the numbers of renewables appear to be relatively distinct in the European context:

In comparison with established forms of energy production (e.g. coal, gas or nuclear), the geographical distribution of renewables coincides less with that of energy consumption. Given that energy systems in Europe are (semi-) integrated, this has a rather pronounced impact on the balance of production and generation of energy in neighboring countries. This situation is complicated further by the fact that energy production based on renewables is very volatile. There are differences, of course, for example between wind and biomass, but generally speaking, unilaterally increasing renewables in Europe forces a high degree of intermittency upon countries with energy systems that function largely independent of natural variations.

On this technical level, Germany's Energiewende is no exception compared to other national projects to increase the numbers of renewables. However, in relation to many of its neighbors, Germany's efforts to transform the country's energy system towards renewables, are particularly pronounced. The Energiewende—if implemented as scheduled—will, therefore, strongly change the established structure of the German energy system; and given that Germany is heading for large amounts of wind power, both the geographical mismatch between energy production and demand as well as the intermittency of the German energy system will continue to increase. Germany's Energiewende has, thus, a relatively strong impact on the EU's geo-energy space, and over time the effects will become stronger. Further, taking the size of Germany's economy into account, the impact will be significantly stronger than in other cases of green energy policy, for example, Denmark's *grøn omstilling*.

As regards the economic side of the Energiewende, simply put, each side will attempt to reap its benefits and try to avoid its costs. The instruments used in this context may encompass strategies such as remaining indifferent towards certain developments, activities to ensure control over the national system, attempts to ensure or to gain control over other parts of the European energy system and its evolution, or any other measure deemed applicable under the thin structure of European energy policy.

Given that renewables are in many (if not all) Member countries the fastest growing segment of the energy sector, policies to massively increasing their numbers on the national level can, therefore, be described as a highly dynamic element in the relations between the EU Member States. And as the example of Germany's Energiewende shows, the resulting dynamics have the potential to either increase the EU's internal cohesion or to put it further into question—if the Member States do not weigh their national standpoints very carefully against the overarching aims of European energy policy. Another important point to consider in this regard is the right level of coordination: The effect of national renewable energy projects of a magnitude such as the Energiewende is strongest on the macro-regional level. This level of the political system should, hence, serve as the main arena for the political discussions involved with introducing renewables.

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Chapter 7
China and Renewables: The Priority of Economics over Geopolitics

Duncan Freeman

7.1 Introduction

As a result of the rapid growth in its economy since the 1980s, China has in a short time become a major global economic and political actor, and has emerged at the center of the world energy stage. China's rise, especially in economic terms, has made it one of the most important actors in the global geopolitics of energy. From the international perspective, China constitutes a list of energy superlatives: as a state it is the world's single largest consumer and producer of energy, the biggest consumer and importer of oil, the largest producer, consumer and importer of coal, and by consequence also the biggest emitter of CO_2 (EIA 2015). Thus, its direct global impact across a broad range of resource, environmental and economic and political problems, including energy geopolitics, is huge. Within China itself, discussion of the geopolitics of energy has focused on access to fossil fuel resources, primarily oil and gas from the Middle East, Central Asia and Russia, although it is also considered as a factor in the disputed claims to sovereignty in the East and South China Seas. While China by dint of its energy demand resulting from economic growth has come to be a major actor in the traditional geopolitics of global fossil fuel resources, its role in renewable energy sector is if anything even more overwhelming. China is currently the biggest investor in renewables, the largest deployer of wind, solar photo voltaic (PV) and hydro power, its companies are among the leading producers of wind turbines, solar modules and equipment for hydro power stations, and they are increasingly active not only within China but also in global trade and investment in these sectors, as well as in related industries such as power distribution infrastructure, electricity storage, electric or new energy vehicles and even the digital economy (REN 2016). More than any other state, the

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geopolitics of renewables will become manifest through the actions of China, although how this occurs is likely to be unique to its own circumstances. Given its leading role in renewables, the importance of China as an actor will be demonstrated in the renewable energy sector itself, but also by its impact on other related sectors, especially fossil fuels, in which the geopolitical dimension will be determined by the policy priorities of the Chinese government.

Almost nothing that China does in the area of renewables is without global impacts, which are complex, and extend well beyond the simple problem of production and consumption of energy. After the election of Donald Trump as president of the US and his apparent rejection of a global system in favor of putting America First, including in the area of climate and energy policy through withdrawal from the Paris Agreement, the administration adopted a slogan of "energy dominance" through revival of fossil fuels. The EU has reaffirmed its commitment to the Paris Agreement, and continues with its Energy Union. President Xi Jinping asserted China's claim to a leading global role in a speech to the World Economic Forum in Davos in 2017 that was in part based on its leadership on climate change, and which also follows from Xi's earlier call in 2014 for an "energy revolution" in China (Xi 2017; Xinhua 2014). Thus, even if the share of renewable energy production and consumption in China may still be relatively small compared to traditional fossil fuels, it is now one element in how the Chinese government conducts international relations.

Within China, the distribution of wind, solar and hydro-power already poses challenges to their exploitation, as the location of their most abundant and efficient sources in the interior is generally distant from the areas of greatest demand in the coastal regions. Nevertheless, outside the borders of China, the geopolitics of renewables has little meaning in the sense of territorial control of energy resources. As yet, the transport of renewable energy to China is not a feasible proposition nor is its export. This does not mean that China is not willing to be a global actor, and apart from its huge role in trade in solar PV and wind power equipment it is also already a major investor in renewable energy generation projects, although unlike fossil fuels extraction, these serve local markets rather than domestic Chinese energy demand. China's gains will be through the returns on investment in such projects and trade in technologies in the sector. Nevertheless, such trade and investments raise questions of control and security that may invoke a geopolitical dimension. Trade disputes in the renewable sector involving China and the US and EU have been frequent. There is an increasing tendency to securitization of foreign direct investment in the US, especially that from China which is now the leading target for review on security grounds (Reuters 2017). In 2017 the EU set out a similar policy goal for "strategic industries, infrastructure and key future technologies" (European Commission 2017).

Until now, however, China has given almost no attention to the geopolitics of renewables as it has been traditionally construed in the fossil fuel era. Neither in official or academic discussion has the development of renewables been viewed as geopolitical problem. The Chinese government recognizes the fundamental importance of energy. As the Strategy for an Energy Production and Consumption

Revolution published by the National Development and Reform Commission said, "Energy is the material foundation of the development of human society, and energy security is a major element in national security" (NDRC 2016e). While renewables are central to the revolution, this has not given them the same geopolitical dimension as traditional energy sources. The Chinese government views the development of renewables as first an energy supply issue, and in wider domestic policy terms it is related to the problems of environment and climate change, which extended internationally through actions such as China's commitment to the 2015 Paris Agreement. For the Chinese government, however, a core issue is not exploitation of renewable energy resources in themselves, although this is important, but rather the technologies, industrial processes, markets, trade and investment that enable this to occur. This has international consequences, but they are not equivalent to those for fossil fuels. Unlike in the case of fossil fuels, no country has yet invaded another to annex control of solar or wind resources, but what the media like to refer to as "trade wars" have already occurred in these sectors, as governments seek to control the industrial growth potential of renewable energy. In China, with its own renewable energy resources at least in theory sufficient to meet its needs, the geopolitics of renewable energy ranks far behind the economics or industrial policy of renewable energy as a priority.

7.2 Resources

After almost four decades of rapid, though uneven over both time and space, economic growth, calculated on a Purchasing Power Parity (PPP) basis China's Gross Domestic Product (GDP) is the largest in the world (IMF 2017). Access to sustainable energy supplies is vital to China maintaining its economic development, even as the energy intensity of the Chinese economy has declined significantly since the 1980s (NDRC 2016a). China's economic growth since the late 1970s has been based to a considerable extent on plentiful domestic energy resources, although supply imbalances have occurred when energy production has failed to keep up with rapidly growing demand. Energy production and consumption in China has been based on coal, which at its recent peak share in 2007 supplied 72.5% of energy consumption, although by 2015 this had declined to 64% (China Statistical Yearbook 2016). China, which has the world's largest coal reserves, produces and consumes over half of coal mined globally (EIA 2015). China produces domestically 85% of its energy consumption, and its import dependence is thus relatively low compared to many economies, although it is rising (IEA 2017). In particular, China's oil demand can only be supplied in large part by imports, as in the 1990s it became a net oil importer, which raises problems of strategic vulnerability. As part of its energy transition in order to reduce coal consumption, China has increased reliance on gas, much of which is also imported. This increasing import-dependence for oil and more recently gas has placed China at the center of energy geopolitics both in terms of its policy and as an object of analysis.

Discussion of energy geopolitics in China has traditionally concentrated on the key question of supply of oil, and more recently gas, and has been concerned with both sources and supply lines in critical regions such as the Middle East, Africa, Central Asia and Russia (Yang 2009; Chen 2012; Zhang 2014; Dong and Cheng 2015; Yang et al. 2015). From this perspective, energy is a question not just of energy security but also of national security. This focus has also been adopted in many analyses of China's energy geopolitics from the non-Chinese perspective (Ebel 2009; Jaffe et al. 2015; Petersen and Barysch 2011; Rosenberg et al. 2016).

In contrast to oil and gas, China's renewable energy resources are relatively abundant. Although the degree to which they may actually be exploitable is the subject of debate, China's renewable energy resources are in theory at least sufficient to meet foreseeable future demand (Hoogwijk and Graus 2008; McElroy et al. 2009; Moriarty and Honnery 2012; He and Kammen 2016). Hydro, solar and wind renewable energy resources are widely distributed within China, but their distribution is far from ideal from the point of view of effective exploitation, as there is a significant disparity between the location of the most abundant resources and the regions of greatest energy demand. Whether they are wind, solar or hydro, all these resources tend to be concentrated in the interior in the west or north of China, distant from the main concentrations of population and economic activity in coastal provinces in the east and south.

This distribution of resources presents a significant challenge for the domestic deployment of renewables. While China has gained recognition for its huge domestic investment in renewables, and its rapidly increasing installed capacity, it has faced serious difficulties in actually bringing this online. Curtailment has been a significant problem for China's renewable sector. One of the main causes of the curtailment it the lack of grid connection and capacity linking solar and wind farms in the main generating regions to the consuming provinces. While curtailment is a general problem in China, it is severe in those provinces with the highest capacity. According to government statistics, in 2016, in Inner Mongolia, which has 17.2% of China's grid-connected wind capacity, the curtailment rate was 21%, while in Xinjiang, which has 11.9% of capacity, it was 38%, and in Gansu, with 8.6% of capacity, it was 43% (NEA 2017). Investment in generating capacity has run ahead of transmission infrastructure, although ambitious plans for expanded grid are being implemented. But, infrastructure is only one part of the problem, as policy failures, especially to ensure that electricity generated from renewables is taken up by power companies, are also a cause of curtailment.

Up until now, China's exploitation of renewable resources by electricity generation and distribution has been entirely a domestic problem. To a considerable degree it is similar to that which has in the past affected the exploitation of coal, for which the main deposits are also in the interior in regions that generally correspond to the wind and solar resources. One solution, the physical transport of the energy source by road and rail, is not available for renewables. The national Ultra High Voltage grid infrastructure that has been developed has been intended for long-distance transmission of electricity from the main coal and renewable bases to consuming regions, and will in future increasingly serve the latter (NDRC 2016c).

Although the policy direction of reducing the role of coal and increasing that of renewables is clear, distribution infrastructure will continue to serve both, but place limitations on the domestic exploitation of renewable energy. Similarly, the policy problems of take up by energy providers, although they are being addressed (NDRC 2016d), will continue to slow the growth in utilization of renewable resources.

Unlike for key fossil fuels, China's renewables sector is not directly dependent on energy imports. Nevertheless, it is not entirely free from import dependence. The renewable sector has been dependent on technology imports in the past, indeed in the early 2000s foreign companies dominated the market for wind turbines in China. China's industrial policy has attempted to reverse this situation, and create an industry based on domestic technology (SETC 2000). The sector also requires raw materials inputs for which in some cases it is largely dependent on imports. One such case is polysilicon, the key raw material for solar cells. Although China has some polysilicon producers, the industry remains dominated by Western companies for its raw materials. There have been periods of overproduction in the polysilicon sector, resulting in low prices, which has benefited Chinese solar panel producers, but shortages have also created severe supply difficulties and high prices for them in other periods, placing cost pressure on China's manufacturers and causing them losses. The raw material has also been the subject of trade disputes, as in 2014 China imposed anti-dumping and anti-subsidy duties on imports from the EU, the US and South Korea.

The reverse situation has occurred with rare earth elements, which are an important input for wind turbines, and for which China is the dominant producer. The strategic question arises because China has the largest reserves of rare earth elements, an estimated 44 million tons out of a world total of 120 million tons, but even more importantly, dominates global production. In 2016, China's official production quota was 105,000 tons out of a global total output of 125,000 tons (USGS 2016). The concern for non-Chinese consumers focused not only on the use of rare earths in wind turbines, but in many other strategic sectors. The question goes beyond China's mine production of rare earths, and includes government industrial policy concerning their use, which in effect seeks to ensure that downstream processing and application also occurs in China (Humhries 2012; Massari and Ruberti 2013; Gholz 2014; Golev et al. 2014). Hence, the key question is not only control of rare earth metal resources, but also of their application in technology, production and markets. A case brought against China by the US, EU and Japan at the World Trade Organization resulted in China having to remove its export quotas on rare earth metals in 2014. Other inputs for wind turbines and their towers, such as steel, present less of a problem for Chinese producers. China's steel output is by far the largest in the world, although steel prices vary depending on output from the sector and market demand. In periods of high demand for steel costs for turbine producers and consequently for investors in wind power projects have risen. In general, the key material inputs for the renewables sector are supplied on domestic and global markets in which Chinese companies are a major force both as buyers and sellers, and where they have considerable market power.

Although wind and solar attract the most attention, hydropower has long been the largest source of renewable energy in China. In the 1990s the construction of the Three Gorges Dam on the Yangtze River was a manifestation of the strategic importance of hydropower in the development strategy of the Chinese government. While China has constructed the largest hydropower fleet in the world, in recent years, increasing policy attention has been given to wind and solar PV, and indeed these sectors have grown more rapidly than any other in terms of their contribution to renewable energy production. Nevertheless, hydropower is one sector where geopolitics is arguably significant in China's international relations. The control of rivers has been a subject of disputes between China and neighboring states over many years and the increase in dam building in China, with many large projects planned, has added to the concerns of downstream states, most notably India. The problem concerns not only hydropower, but also other problems, which may be even more fundamental, such as water access and irrigation. The Chinese government's ambition to use rivers as a major source of renewable energy brings traditional geopolitical concerns over the control of water resources to the fore. In this case, however, there is a considerable history of dealing with such issues (Biba 2012; Ho 2014). However, the increasing demand for energy, and the use of hydropower as a source of green energy, will create greater pressure on the traditional systems in place for dealing with cross border issues related to water resources.

7.3 Policy

The history of renewable energy development in China is long, and in the case of solar PV and wind power dates back to the 1980s, but its current prominence is relatively new. Policy on renewables in China is not only related to energy supply itself, but concerns climate and environmental policy, and also industrial policy and economic development priorities.

The modern development of wind and solar energy in China dates back to initial strategic R&D programs launched by the Chinese government in the 1980s (Li et al. 2007). In the 1990s small-scale experiments in deployment took place, but it was only in the years after 2000 that large-scale industrial application began with government policy support for deployment developed on a wide scale. Detailed policy on their deployment began to be adopted in the early 2000s, and renewables were included in the 10th (2001–2005) and 11th (2006–2010) Five Year Plans. China's energy policy in the 2000s was first driven by the necessity to improve the security and sustainability of energy supply, which gave impetus to broad initiatives in areas such as energy efficiency and also alternative sources to traditional reliance on coal, especially for electricity generation. Later environmental and climate change considerations also began to figure strongly as a factor in China's energy policy and support for renewables.

Renewable energy development has become central to China's response to the challenges of climate change and environmental degradation. The problem of environment and climate change began to reach the top of the policy agenda under the leadership of Chinese Communist Party Secretary General Hu Jintao and Premier Wen Jiabao in the decade after 2004. Although China was heavily criticized at the Copenhagen Summit in 2009, the government had already begun significant investment in the deployment of renewables, moving beyond previous focus on hydro power to deployment of wind and a lesser extent solar PV (State Council 2008). Under the new leadership of President Xi Jinping since 2013, the government has pushed these goals even more strongly. Xi Jinping himself has called for an energy revolution (Xinhua 2014), and has entered into international commitments such as the joint announcement with President Obama in 2014 (Whitehouse 2014). The Chinese government has ratified the Paris Agreement of 2015, and despite the threat of the US under President Trump to withdraw from it and his steps to favor fossil fuels over clean energy, has shown no signs of altering its policy direction.

Beyond the increased concern for the environment and climate change, the deployment of renewables in China is closely related to industrial and development policy. Unlike in much of the West, where the subject is still debated, especially in the US under the Trump administration, the Chinese government from early on adopted the position that support for climate change mitigation and for renewables was a positive economic development opportunity (Freeman 2010). This is related to the long-held Chinese government position that climate change itself is primarily an economic development problem, and policy to deal with climate change is an opportunity to transform the structure of the Chinese economy and develop new industrial sectors where China can become a global leader. At a Politburo meeting in 2010, Hu Jintao, the Chinese Communist Party Secretary General, asserted the principle that, "tackling climate change was a key strategy for China's social and economic development and a major opportunity accelerate the transformation of the economic development model and adjust its economic structure" (Xinhua 2010). This view was embodied in policy documents such as the Medium- and Long Term Renewable Energy Plan adopted in 2007 which set goals not just for deployment of renewables but also for the establishment of a domestic industry in the sector (NDRC 2007). Subsequently, renewable energy became central of China's economic planning in both the 12th Five Year Plan (2011–2015) and 13th Five Year Plan (2016–2020), where renewables were designated as industrial sectors in which government support for growth will be concentrated. According to one estimate, in 2014 6.9% of central government expenditure was related to climate change adaptation and mitigation, much of which goes directly to industrial supports for renewable energy (Su 2015).

The Chinese government, more than any other major international actor, has recognized the potential of the renewable energy sector as a driver of economic development and incorporated it into a forceful industrial strategy. China's commitment to what has come to be called "green growth" has placed renewables at the center of industrial as much as energy or environmental policy. Thus, from an early stage development of renewables, energy and industrial policy have been closely linked, but the geopolitical dimension of renewables has been absent from the government's strategy. Chinese policy documents concerning renewable energy focus on climate and environmental issues, and also economic and industrial policy, but geopolitics do not figure in the discussion. For instance, in a speech on green and sustainable development in 2012 at the global energy summit, Premier Wen Jiabao focused on sustainability and renewable energy, and although he addressed the international dimension of the question, he ignored geopolitics, discussing the need for global cooperation instead (Wen 2012). More recently, in a domestic setting, Li Keqiang, Wen's successor as Premier, discussed renewable energy in the same terms at a meeting of the National Energy Commission in 2016. While he emphasized the importance of energy for China's development, his reference to renewables focused on energy transformation and sustainable development. Li's discussion of the international dimension of energy also focused on cooperation, and the need to create diversified supply, but he did not refer to renewables as having any specific role in this problem (Li 2016).

While they may have been important for China in fossil sectors, strategic geopolitical concerns of security of supply have not been central to government support for renewables, and this remains the case. Import dependence has given fossil fuels an explicit geopolitical dimension for China, notably in the oil and gas sectors, where control of resources and transport routes has been a central geopolitical concern. But renewables have no traditional geopolitical dimension in China's policymaking for the sector (NEA 2016a, b, c, d; NDRC 2016a, b, c, e). The Strategy for an Energy Production and Consumption Revolution published in 2016 discusses the international dimension of renewables, and focuses on the possibilities of cooperation rather than geopolitical competition (NDRC 2016e). Still, it also argues that the revolution will increase China's capacity to guarantee energy security and raise the overall level of national security. Furthermore, an energy revolution will enable China to have greater influence in the field of international energy.

From the Chinese perspective, technology, production and markets are equally as important, if not more so, than development of renewable energy resources themselves. Industrial policy and economic development are fundamental to Chinese approach to renewables. Thus, the global distribution of renewable energy resources is less important than the development and control of technology, production and markets. The key dimension for China has not been control of wind and solar energy resources themselves. International trade and investment flows in the wind, solar PV and hydro power sectors are as important as flows and distribution of energy.

Beyond China's borders the key battles have not been for control of renewable resources themselves, but over trade and investment, and reflect the wider economic significance of renewables as industrial sectors. Both exports of solar modules and wind turbines from China have been targets for trade defense measures in the EU and US. Thus, the use of trade defense measures by the EU and US against China's renewable sectors have shown that the belief that wind and solar are key industries is shared among all major economies. The potential economic rather than geopolitical threat posed by China in the renewable sector was clearly recognized by the Obama administration, which argued that sectors such as renewables could not be left to its competitors to dominate: "The path towards sustainable energy sources will be long and sometimes difficult. But America cannot resist this transition, we must lead it. We cannot cede to other nations the technology that will power new jobs and new industries, we must claim its promise" (Obama 2013). The advent of the Trump administration demonstrates that such a position can be reversed in favor of support for fossil fuels, possibly ceding domination of renewables to competitors.

Although geopolitics have not featured in policymaking on renewables in China this does not mean that policy is entirely free of geopolitics, even if it is only indirectly engaged. The secondary effect of renewable development on fossil energy consumption and production, which has been at the core of energy geopolitics, will be important. Even if the China's energy transformation is not yet sufficient to free it from the constraints of dependence on fossil energy sources, including those that are imported, the development of renewables will have an impact to the extent that it reduces reliance on them, especially coal, where China dominates global production and markets. Oil, by contrast, is not directly impacted by renewable replacement, which primarily impacts electricity generation, i.e. coal and gas, but it will, however, be affected by parallel developments such as increased use of electric vehicles.

The outcomes of China's policy will be far from straightforward. The Chinese policy system is complex and uncertain in its outcomes. As already noted in the case of deployment of renewables, the complexity of Chinese government policy environment has had a considerable effect on the domestic development and deployment in the sector, but this also feeds through to the international impacts of China's renewable sector. While China has placed increasing domestic emphasis on the deployment of renewables, despite clear policy priorities set by the central government, the development of renewables remains in a state of flux. Competition between renewables and coal is intensified by the structure of China's political system, where both central and local government authorities are significant actors, with priorities that often conflict. Thus, while central government policy may target the expansion of non-fossil fuel energy and the reduction of coal in particular, there are conflicting interests where local governments do not follow policy laid down in Beijing.

7.4 Strategic Considerations and the Future

The strategic question of energy security has been a focus of Chinese government policy with regard to fossil fuels. The Chinese government recognizes that renewables may have an impact on energy security and even national security, but policy does not directly address strategic geopolitical considerations of the development of renewable energy. China has focused on domestic renewable energy development, with economic development and industrial priorities being given as much emphasis as purely energy considerations. These priorities are have also previously been reflected in the Chinese government's resistance to efforts mainly by developed Western states to securitize climate change as a national security issue (Freeman 2010). The Chinese government has insisted that securitization is a distraction from the real problems of climate change mitigation, which is an economic development problem. However, despite the lack of explicit geopolitical content, the development of renewable energy in China is not without impacts in these areas.

Prior to the conclusion of the Paris Agreement in 2015, most states had come to the conclusion that renewables were not just central to climate change mitigation, but were also key to future economic growth. The idea of "green growth", while not accepted unanimously, had become part of the consensus on which the Paris Agreement could be built. Global competition for the best technological solutions at lowest cost would push forward climate mitigation and economic growth. China has been at the forefront of this thinking. Not only in domestic markets, but also globally, it has been a key factor in the declining cost curves for renewables. As already noted, renewables have not only been central to China's climate and energy policy, but also industrial policy. The result is that China seeks to capture the economic as much as the purely energy or environmental benefits of the development of the sector. By means of China's domestic developments in renewables, their global impact through trade and investment also creates the possibility for other states to benefit from a move away from fossil fuels. Although not all the technological foundations are yet in place for generation, transmission and storage, China, based on its past performance in creating industrial capacities, is likely to play a central role in making this possible.

Chinese government policy on renewables has largely been domestic in focus, but the renewable energy sector is global. International trade and investment is a central feature of the sector, but unlike traditional fossil fuel sectors it is not the fuels themselves but the means of production that are traded, especially in the solar PV sector (trade in the wind power sector is much less important, as high transport costs of wind turbines generally force manufacturers to locate close to their markets), where Chinese companies have come to dominate the global industry and have been the target of trade defense measure in the EU and US in an attempt to preserve domestic industries from competition from China. More recently, outward investment by Chinese companies has emerged, as they invest in renewable energy projects. Chinese investment in renewable energy is increasing, and is global in reach (Buckley and Nicholas 2017). For instance, China accounted for 30% of all investment in the power generation sector in sub-Saharan Africa between 2010 and 2015. Of this, 56% was in the renewables sector, and 49% was hydropower (IEA 2016). The objective is different from the traditional competition for resources that has been central to fossil fuels. Chinese companies have invested in wind and solar PV projects that supply energy to local markets. Their motivation has often been the higher economic returns that are available compared to domestic markets.

The Strategy for an Energy Production and Consumption Revolution argues that development of renewables in China, Europe and other locations increases the diversification of global energy supply (NDRC 2016e). In this argument, increasingly competitive markets including renewables bring global benefits by advancing the shift away from fossil fuels controlled by a limited number of suppliers. China, by supplying the means of producing renewables at low cost strengthens this diversification of competition. However, against this runs a counter current of concerns in other major economies such as the US and EU that China's dominance of renewables and other related sectors may be as problematic as that posed by dominant fossil fuel suppliers. Thus, trade defense and other measures, as well as domestic supports, to counter Chinese competition may increase, especially at a time when economic nationalism is a growing political force in many countries. The renewable sector has competitive and cooperative dimensions in relations between states, but it is increasingly the field of industrial competition. This is likely to bring continued friction not just in trade and investment in key technologies, but also in raw materials such as polysilicon and rare earth metals where China is a dominant producer or consumer.

In China, the focus on electrification of the energy system in order to deploy renewables has focused on large-scale projects for production and distribution of electricity. One of the greatest challenges to the deployment of renewables has been the provision of infrastructure and policy environment to ensure the uptake of electricity generated. While renewables have been used to provide energy off-grid in isolated areas in China, by far the largest resources have been invested in generation and transmission through large-scale grid-connected projects. Investment has not been confined to within China, and Chinese investors have invested in renewables capacity in solar PV, wind and hydro power on a large scale in many countries. One company, State Grid, which controls about 80% of China's domestic grid, has also made investments, in grid networks in many countries, often through investment through minority holdings in existing companies. This has so far had little wider impact on the grids themselves, even though holdings in several EU member states suggest the possibility of China playing a role in national and regional integration outside its borders.

The rise of China brings to the fore wider strategic interests that may increasingly encompass those that impact on renewable energy. The current strategic vision of China formulated in the Belt and Road Initiative (BRI) which was launched by Xi Jinping in 2013 is based on the idea of building connectivity, primarily through the construction of infrastructure. As yet, renewable energy has not been specifically addressed by the Chinese government as part of the BRI. At the Belt and Road Forum for International Cooperation held in Beijing in May 2017, which was attended by 28 heads of government or state, a list of deliverables was promulgated, among which were the Vision and Actions on Promoting Energy Cooperation on the Belt and Road (National Energy Agency 2016c). This document, which again does not specifically mention renewables, seeks to portray the initiative related to energy in non-geopolitical terms, and focuses on cooperation. Nevertheless, even if it does not include renewables, the BRI will raise geopolitical concerns in those regions which it incorporates, especially Central Asia, where China's energy interests are already significant. Another Chinese initiative, while still distant possibility, may raise renewable energy to a real geopolitical issue: the proposal from China for the creation of a global energy grid (China Daily 2016) which has been espoused by State Grid and also by President Xi Jinping at the United Nations (Xi 2015). This proposal for a global grid network, which would allow for regional balancing of renewable energy sources, would raise questions over control and distribution of renewable energy resources that have in the past been the focus of the geopolitics of oil and gas.

7.5 Conclusion

Geopolitical analysis of energy in China has generally been framed in similar terms to those used in the West, and focused on problems of securing access to fossil fuels. The emergence of renewables as a significant factor in energy systems raises new questions not just for China, but also globally. Until now, China has not sought to give an explicit answer to these questions. However, the policy adopted by China on renewables provides some implicit answers. First, and foremost, China's policy on renewables has been domestic in focus, and while energy supply and security, climate change and environmental degradation are key considerations, renewable energy is framed as an economic and industrial development priority. The energy resources and the means to exploit them are equally important in advancing economic development. The existing limits on transport of renewable energy mean that traditional energy geopolitical approaches have been largely redundant. Thus, while China's renewable energy companies have a global impact, the traditional geopolitical aim of providing energy supplies to the home country has been almost entirely absent. China has focused on a strategy of creation of domestic national technology, production and markets. The external impacts have been by-products rather than the focus of its strategy. However, in trade and investment in technologies, China is key. The result in economic terms has been competition in renewables and also with fossil fuels.

The fact that hitherto traditional geopolitics of energy have been absent from China's policy, does not mean that they will remain so. The potential integration of China into renewable energy networks beyond its borders raises the possibility that concerns for security of supply will become a question of geopolitics. In strategic projects such as the BRI, which include an energy dimension, China's government has been careful to avoid rhetoric that could be interpreted as demonstrating designs on domination of participating countries, preferring instead to speak the language of partnership and cooperation. The centrality of domestic development priorities leads to growth of renewables in China itself, and has also made it a leading global force in the renewable sector. However, this raises the possibility of international conflicts that are primarily economic rather than geopolitical, and which are already manifested in so-called trade wars. As yet the economic and even security interests manifested in the renewables sector have yet to give rise to traditional geopolitical calculations.

More broadly, China has sought to present its rise as being outside the parameters of traditional paths of rising powers as they are interpreted in the West. While China has to a significant extent escaped the limits of development paths prescribed in the West, its economic success manifested by GDP growth has opened it to dependence, especially in the area of oil and gas. Energy policies such as the development of renewables give China the possibility to escape some of the existing geopolitical constraints, although it may in the longer term bring new challenges. Although it is not spelled out by the Chinese government, the focus on economics in development of renewables has a potential geopolitical dimension, helping China to liberate itself from some of the existing energy constraints which it faces. The lack of any explicit geopolitical element in China's consideration of renewables does not mean that the implications are absent. Renewables present a challenge to traditional geopolitics of energy and China will be central to how this develops. China's approach to date suggests that the economics and industrial exploitation of the R&D, production capacities and markets for technologies will be as important as the geopolitics of renewable energy.

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Chapter 8
Drivers, Apparatus, and Implications of India's Renewable Energy Ambitions

Kanika Chawla

8.1 Introduction

Energy issues have historically been deeply interlinked with foreign policy, national security, and regional and global geopolitics. As early as in 1911, Winston Churchill, made the decision to change the Royal Navy's primary fuel from coal (which was mined locally in Wales) to oil imported from Persia (Munsen 2013). This resulted in countries around the world using their foreign policy to access energy sources beyond their shores. Even as fuel choices and energy systems evolve, strategic energy policy decisions are deeply interlinked with foreign policy. The bi-directional relationship between foreign policy and domestic energy policy has come to be a defining political variable of our times.

A little over a century later, China and India are leading the growth in new demand for oil and gas, and other energy and non-fuel mineral resources. In 2009, China became the world's largest energy consumer. In the first decade of the 2000s, the share of China and India in global fossil fuel trade more than doubled in value terms (to 10.8%). Recognizing the shifts and the proactive strategic action China is taking to deepen its energy cooperation, it is imperative for India to ask itself whether its commercial, diplomatic and military weight are in tune with its energy needs in the coming decades. With a population of about 1.25 billion and a purchasing power parity GDP per capita of nearly USD 6100 (World Bank 2016), India is in the midst of a huge transformation as it remains the fastest growing G20 economy. In order to keep pace with the growth, between now and 2030, Indian energy demand is projected to increase more quickly than any other G20 country.

India's modern energy system is already sizable, with the world's third largest electricity generation capacity. However, in addition to the growing demand as a result of economic growth and growing share of manufacturing, there continues to

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be unmet latent demand from unelectrified rural households. About 75 million households, a third of the total, are not connected to grid electricity, and 75–80% of rural households use traditional biomass as a primary source for cooking.

India's energy future is constrained by the limited availability of carbon space, and influenced largely by its vulnerability to climate-related stress. For this reason, India could benefit from the considerable research and innovation taking place globally on cleaner energy sources. It could use such research to leapfrog to cleaner and more efficient technologies. It is in this context that India's commitment to forging partnerships on clean energy is increasingly important. In the last three years, more than ever before in Indian diplomacy, energy related diplomatic and commercial outcomes have become a growing feature of government to government cooperation. Much of this focus has been on non-fossil fuels.

However, the real energy cooperation story that is emerging between India and its multiple diplomatic partners is the one on renewable energy and sustainable development. Japan committed to conducting feasibility studies for a 10 MW canal-top solar photovoltaic plant in Gujarat, even as large Japanese private capital committed to flow into grid connected renewable energy projects in the country. Before the recent change in administration, the United States had become a trusted partner, supporting the development of smart cities in Ajmer, Visakhapatnam and Allahabad. It also helped strengthen the Partnership to Advance Clean Energy (PACE), launched a Clean Energy Finance Forum, and supported the financing of off-grid clean energy through public and philanthropic money. Germany, an established partner, committed to support India‘s aggressive target of 175 GW of renewable energy by 2022, particularly for the scaling up deployment of solar rooftops as well as the green energy corridor project which aims to promote the integration of renewables into the grid by strengthening the transmission network.

Oil, gas and coal will continue to play an important role alongside this rapidly evolving deep energy diplomacy around renewable energy. Daily oil imports will triple for India by 2035 (Ghosh 2015). As recently as 2014, India signed agreements on long-term oil and gas cooperation, including liquefied natural gas (LNG) supplies and studying the viability of a pipeline connecting Russia and India.

In the 25 years since India's balance of payment crisis of 1991, which resulted in the opening up of the Indian economy to the global economic order, India has carved an important role for itself in evolving geopolitical matters. By 2030 India's share in daily oil trade is expected to be 12.5%, up from 7.4% in 2014 (British Petroleum 2015). For comparison, the share of the United States in global oil imports was 26.4% at its peak in 2005; the equivalent figure for the European countries [excluding Central Europe] was 38% in 1980 (Bery et al. 2017). The imperative of improved energy access that stems from economic growth, including increasing rates of rural to urban migration, will ensure that energy demand will become an important driver of India's foreign policy. India is on track to assuming the role in global energy trade that Europe played in the 20th century. While not the largest energy consumer, India is poised to be the "swing voter" in global energy markets with strong national interest in well-functioning markets.

While India is cognizant of the multiple risks that plague its energy sector, and is consciously taking strategic speculative positions by balancing multiple energy sources and energy partners, the policy and regulatory apparatus must continue to balance the domestic drivers of energy demand and their implications on foreign policy. This chapter explores the strides taken in renewable energy policy domestically, as well as the geopolitical implications of India's renewable energy dreams.

8.2 The Evolving Energy Narrative

This chapter summarizes India's unique clean energy transition and its drivers, means, and outcomes, focusing on the impact on actors, foreign policy, and inter-actor relationships. The narrative around the political economy of renewable energy is limited. The narrative on the political economy of energy in India is even more scarce. However, given the mammoth economy wide impacts of energy prices, political economy provides a nuanced lens to look at India's energy transition. Much of the energy discourse in India pertains to the technical aspects of India's energy system, with estimations of demand and focus on sources of supply. However, this chapter focuses on the socio-economic drivers of renewable energy policy, and the political and diplomatic ramifications of the energy policy evolution.

As India's energy system moves away from the autarchy of its past, parts of what has traditionally been a largely government dominated sector has begun to be privatized. However, the deepening of international energy relationships and the modernizing of its energy governance is not enough. India needs to build institutional capacity to deal with the complexities of greater integration into international energy markets. In order to accomplish this, India must keep in mind the following about its specific context.

First, India, like all energy dependent countries, is exposed to both supply risks (war, strikes, or political upheavals in oil exporters and deliberate blockades) and market risks (price volatility).

Second, while its investments in equity oil have so far had limited impact in reducing exposure, India has been slow to engage in regimes designed to manage resource dependencies, remaining outside all major multilateral and plurilateral energy regimes (this has changed as recently as April 2017, when India has joined the IEA as an Associate Member). It will need allies in these forums, including the G20, where an Indian presidency could shape international cooperation on energy security.

Third, India's resource needs and environmental challenges are complex. Hydroelectricity is affected during times of drought; oil (a major source of agricultural energy) has an impact on food inflation; and climate change will only serve to multiply these risks, making energy infrastructure vulnerable to extreme weather events.

Fourth, the intersection between maritime and energy security is a potentially serious source of friction. India‘s broader region encompasses three of the most important choke points for world oil flows: the Straits of Malacca, Hormuz and Bab el-Mandeb (between Yemen and Somalia). But India or China alone cannot protect the sea lanes (oil transit volumes through the Strait of Malacca alone will rise to 45% of global trade in 2035).

Bearing these in mind, this chapter analyses the political economy of India’s renewable energy ambitions, deployment, and energy transition. The narrative ahead first analyses the drivers of clean energy adoption. India’s domestic national development priorities have led to its renewable energy ambition. The analysis details the role and impact of renewable energy in advancing each of these national development priorities. Building on the phases of the renewable energy transition in the country so far, the chapter also explores the apparatus used to design, implement, and monitor the scaling up of renewable energy. The policy framework for renewable energy has evolved over time, the changes have been assessed to understand the underlying social, political, and economic motivations. The facilitative framework for renewable energy has also been decoded to understand the role of and impact on the multiple actors in, and associated to, the renewable energy sector. This includes actors at all levels of governance, power generators, transmission companies, distribution companies, financiers, and consumers. In order to accurately describe the political economy of renewable energy, the interlinkages and complex relationships between the various actors are key. The coordination process between multiple layers of governance in policymaking and implementation, as well as with non-political actors is assessed in some detail.

In order to further accelerate the pace of renewable energy transition in India, as well as a result of the existing renewable energy deployment, India has made some strategic foreign policy plays. These include forging new bilateral, plurilateral, and multilateral partnerships to advance shared priorities on renewable energy, even as relationships on other more conventional fuels continue to evolve. The foreign policy impacts of these new relationships, and India’s role as a rapidly growing energy market balancing both energy security and sustainable development, are fascinating. While the full extent of the impacts of India’s renewable energy priorities remains to be seen, this chapter delves in detail on the current impacts on the country’s foreign and domestic policies.

8.3 India’s Renewable Energy Transition: Balancing Development and Security

India’s renewable energy growth has historically been driven by a domestic political economy centered around finding an appropriate and cost-effective balance between different energy sources and various categories of energy consumers. While contestations between different interests at the domestic level will continue—and even grow to an extent—the international political economy of energy, particularly renewable energy in particular, will assume greater political significance in the near to medium term. In the long run, India's energy sector might see a new equilibrium. At this stage, however, it would be foolhardy to attempt any deterministic forecasts, given the pace of change the sector is currently undergoing.

8.3.1 State of the Renewable Energy Sector

India ranks sixth in the world in total installed renewable power generation capacity after China, the US, Germany, Spain and Italy. In early 2015 it set a target of 175 GW of renewable energy capacity by 2022, implying that renewable energy would contribute close to 20% of the country's total power consumption in 2022. The Government has raised the solar power capacity target from 22 to 100 GW by 2022, while the wind capacity target was set at 60 GW. There are also targets of 10 GW for biomass and 5 GW from small hydropower for 2022 (Niti Ayog 2016).

India's nationally determined contributions (NDC) committed to the UNFCCC as per the Paris Agreement further build on its already aggressive renewable energy and non-fossil energy targets. The principal contribution as per the NDC will be a transition to 40% non-fossil electricity capacity, this would mean a four-fold increase in absolute terms over today's non-fossil installed capacity. India's current non-fossil fuel capacity stands at 84.5 GW (37 GW of renewable Energy, 5.5 GW of nuclear and 42 GW of large hydropower). This implies that of the current total capacity of 277 GW, non-fossil fuels contribute 30%. The INDC target of 40% non-fossil fuel capacity by 2030 would require India to have close to 320 GW of collective renewable energy, nuclear and large hydropower capacity. As India's total electricity capacity grows less than three times between now and 2030, the non-fossil fuel capacity would have to quadruple to reach the target of 40% share. This capacity target would result in 30% of electricity generation coming from non-fossil fuel sources by 2030, nearly double the share of non-fossil fuels in the current final electricity consumption (Ghosh and Chawla 2015).

Despite active political commitment, and a long history of promoting renewable energy, India does not have any legislation that makes its renewable energy ambition binding. Thus, the continuity of the renewable energy transition depends very much on political commitment, which in turn depends on the validity of the domestic drivers of the transition, and the socio-economic and political benefits accruing from scaling up of renewable energy.

8.3.2 The Many Phases of Renewable Energy in India

India first explored renewable energy sources in the 1970s, in the wake of the oil crisis in the pursuit of energy security, with some early demonstration projects.

The Solar Energy Society of India was established in 1976, soon after the first oil crisis. The Department of Non-Conventional Energy Sources, set up in 1982, was the first of its kind in the world. The second half of the 1990s saw a flurry of wind energy-related industry associations emerging on the scene. The Electricity Act of 2003 and the introduction of the Clean Development Mechanism under the Kyoto Protocol in 2005 were the next broad global developments that gave renewable energy in India a boost. By 2009 the first grid-connected solar project had come up in West Bengal; in the same year, Gujarat was the first state to introduce a solar policy. The National Solar Mission was launched in 2010, with an ambition to install 20,000 MW of grid-connected power capacity by 2022, along with 2000 MW of off-grid power. By 2015, this ambition had been quintupled to 100,000 MW of solar power, along with another 75,000 MW from other sources, primarily wind.

In the close to five decades of renewable energy in India, there have been an equal number of phases that define the emerging renewable energy paradigm. The first phase of renewable energy in India extended for two decades, into the 1990s. During this time, renewable energy continued to be a lab technology, tested through pilot projects, funded entirely through public money. Some of the early stage testing was conducted as part of technical cooperation projects with partner countries, so that technology could progress enough to end the over-reliance on energy imports.

The next phase of renewables, from the mid-1990s till 2010, was dominated by the growth of wind power in wind rich states in southern and western India. The first wave of wind energy adoption was dominated by captive wind power generation to meet power demand. Shortages in power available from the grid, unscheduled blackouts, the high cost of diesel backup, combined with the fiscal incentives available on wind assets made wind power a sound choice for industrial and commercial consumers.

Renewable energy in India got a renewed policy push with the announcement of the National Solar Mission in 2010. As the international climate change discourse reached an impasse at COP 15 in Copenhagen, India found itself isolated, widely seen as obstructing negotiations. China, on the other hand, earned plaudits from the international community for its newfound commitment to several clean energy and other mitigation policies. In the aftermath of this international pushback on India's stand on climate change at the COP 15, the National Solar Mission became a way to demonstrate commitment to mitigation policies.

The Mission was upgraded and its targets revised upwards in the fall of 2014, a few months after the Narendra Modi government took office. In early 2015, the mammoth renewable energy target of 175 GW was officially announced and met with much cynicism both domestically and internationally. In the months following the announcement, and in the run up to COP 22 in Paris, India made its firm political commitment to renewable energy clear. The market responded well to the broad policy signals and begins to rapidly transform, even though several policy and regulatory challenges persisted. While Prime Minister Modi's success with renewable energy in Gujarat primed the ground for him to expand the national targets, it can also be argued that the international political climate in the run up to

Paris was opportune for India to show climate ambition and avoid the criticism that had accompanied its political stance in previous years.

India is now at the cusp of the fifth phase of renewable energy adoption, with renewables (not including large hydro) accounting for a sixth of the total installed capacity. As renewable energy prices decline on the back of technology mainstreaming and supply gluts, the cost of finance remains the final frontier of sorts. It is for this reason that this next phase will focus on market depth. In other words, while technology and policy continue to be important, this phase will focus squarely on financing (including innovation in financing models and the management of risk appetites) in order to make the renewable energy market in the country robust and independent. Accomplishing this will require rethinking incentives, the strategic use of public money, continued policy certainty, and technological upgradation of the grid; even as short to medium term market making instruments could be used to add depth and resilience to the renewable energy market.

The Indian renewable energy sector is picking up pace, and the significant condensing of the period of each of its phases is a telling marker. Additionally, each phase outlines the main drivers of renewable energy: energy security in the post oil-shock world of the 1970s, energy access and aspiration in the post liberalization India of the 1990s, climate change and diplomatic implications of negotiation positions in the target-setting era of the 2010s. The aggressive top down nudges for renewable energy seen under the current regime are motivated by a combination of all these drivers of the past - energy security, energy access, and climate change.

8.3.3 Drivers of India's Renewable Energy Transition

India's growing energy demand uniquely positions it to adopt and deploy renewables at a scale that could surpass other fuel sources. This could be accomplished through the capacity addition of multiple fuel sources (Ministry of Power 2016).

8.3.3.1 Energy Access

The biggest and, in many ways, most difficult shift in India's energy markets in the years to come will be the move from traditional to modern sources of energy. Rising incomes have not yet translated into higher consumption of modern energy in many parts of India, despite long-standing efforts to provide income support, extend the grid, use the public distribution system to provide subsidized energy and introduce modern cook stoves and solar lanterns. In a democracy with a large young population, the drive to move away from traditional fuels will be inexorable.

Ensuring energy access to all households is an essential part of an equitable energy system, and a political priority for governments around the world in countries that struggle with energy poverty. India is no exception: every Indian government since independence has made the availability of basic energy (fuels and services) a priority. Despite rapid strides in adding power capacity, India continues to be plagued by widespread energy poverty. A significant proportion of its population lacks access to clean and affordable energy. Estimates suggest that 75 million households in the country, including almost 45% of all rural households, lack access to electricity (Ganesan et al. 2014a). Advances have been made in extending the electricity grid across the country, but extending it to remote and rural areas is often economically prohibitive and faces the persistent problem of unreliable supply. 750 households would have to be electrified every hour for the next ten years to cover the existing deficit. The challenge is even more severe because of the possibility that such deficit might impede growth, much of which is expected to come on the back of the country's push for manufacturing under the current government's 'Make in India' program.

In order to address rampant energy poverty, India's energy choices must be (and are) geared towards three different segments:

(a) Household energy: which includes lighting, cooking and heating/cooling energy services as consumed within the household. It is in this segment that much of the government's attention is focused, as electoral choices are made at this level. For Indian household consumers, much like the energy poor in other developing countries, grid connected electricity remains the aspirational goal. The narrative around decentralized energy solutions is fragmented, in part because political parties fuel this perception. While several Indian states have encouraged the adoption of solar home systems, and now have mini-grid policies, these continue, in part, to be stop gap solutions. Despite decentralized energy being the more economically viable option than grid extension to remote areas, as well as allowing for easier management and integration of renewable energy supply, the mini-grid business remains fraught with risks associated with grid extension. An effective mini-grid integration practice will become increasingly important as India simultaneously pursues its two energy priorities, towards improved electrification and the scale up of renewable energy.

(b) Community energy: access to energy services for lighting, cooking, heating/cooling, water pumping/purification and other purposes in establishments that deliver community services. Establishments could include rural primary health centers, primary/secondary schools, post offices, farmers' training centers, village/town halls, etc. The provision of electricity at the community level has a strong impact on the region's human development indices. In order for India to make progress on the sustainable development goals, it is absolutely imperative that energy access be extended to community services. Currently as many as 33 million rural Indians are served by unelectrified primary health facilities. This number increases significantly when one considers that 1 out of 2 primary health facilities are either unelectrified or have unreliable supply of electricity. Every second rural primary school is unelectrified, impacting close to 35 million children. However, a growing number of primary health centers and primary schools around the country are being granted financial aid by the central and state governments to install captive solar rooftops to meet their energy needs. In the future, it is possible that primary health centers and schools could be made to serve as appropriate base loads for mini-grid based electricity systems, which could be used to power the entire hamlet surrounding the community service. In order for the national and the multiple state and district level governments to retain political power, India's economic growth will need to be coupled with development on the ground. Renewable energy is now being seen as a vehicle to provide this development in an accelerated, cost effective, and sustainable way.

(c) Productive energy: refers to energy services deployed in income generating activities. These could include, but not be limited to solar-based irrigation systems, agricultural threshing units, milk chillers, solar-based dryers, small-scale desalination plants, etc. The potential of electricity access, including decentralized renewable energy, holds significant potential to improve productivity in rural India, spurring greater incomes and entrepreneurship among rural economies. Apart from providing lighting and digital connectivity services, electricity access can help provide motive power for various agricultural and non-agricultural activities currently mostly met by human power, animal power, or in few cases, by diesel-run engines. Providing electricity for productive uses creates jobs, improves livelihoods, decreases migration, and contributes to the economic growth of the country.

Thus even while battling with the perception of high associated costs and problems of variability, renewable energy offers a viable solution for India's energy access concerns. The costs of decentralized renewable energy, significantly higher than those of grid connected large scale renewable energy, are often the more competitive than the costs associated with diesel power or the costs of extending grid infrastructure to every remote part of the country. Furthermore, the costs of revenue collection in remote areas are non-trivial, making the entire process not just onerous but also one that does not result in any significant revenue. Furthermore, valid concerns around the variability of renewable energy supply are dwarfed when compared to no electricity access at all, or long periods of unscheduled power cuts. Much of rural India is currently powered by diesel (and kerosene in the case of lighting), either as a primary or backup fuel. Renewable energy supply, combined with small batteries and with some diesel backup, offer a more sustainable and affordable solution for rural India. Going forward, it will become increasingly important to design different interventions, business models and financing mechanisms for the different scales of operation. It would serve policymakers and businesses well to recognize that the customer base, the willingness to pay, and revenue models will vary significantly between the three categories.

8.3.3.2 Job Creation

Job creation is a major motivation for India's policy makers. Given the population growth rate of the country, India needs to create 10 million new jobs every year. The employment generation potential of a robust domestic renewable energy market is immense. While India's renewable energy ambitions were not originally driven by the sector's ability to create jobs, the socio-economic co-benefit of a large number of jobs being created by solar and wind power deployment and manufacturing has rapidly become one of the drivers of the transition. Independent analysis shows that solar and wind renewable energy projects have created a workforce (permanently employed) of as many as 21,200 workers (Kuldeep et al. 2017). Renewable energy projects typically create more jobs per unit of electricity than from fossil-fuel-based power, and smaller-scale projects create more jobs than larger ones (Ganesan et al. 2014a). The analysis also shows that as many as 1.1 million full time equivalent jobs could be created if India achieves its target of 100 GW of installed solar energy by 2022. Similarly, approximately 183,500 full time equivalent jobs would be generated if India were to reach the target of 60 GW of wind energy capacity by 2022 (Kuldeep et al. 2017).

The Government of India's priority addressing job creation becomes clear in its directive to ministries to explicitly include the employment generation potential of all new proposals presented to the Cabinet. Recognizing the vast number of jobs that a scaled up clean energy market would create, domestic initiatives that support manufacturing, job creation and skill development have been introduced. For example, solar manufacturing capacity is likely to receive a much needed boost under the "Make in India" initiative. An existing gap and ongoing challenge within India's workforce is the lack of employees trained with the skills needed to construct and operate solar plants. This skill gap is increasingly being recognized as a barrier to realizing the country's renewable energy targets, and is being addressed specifically by recently established Skill Council for Green Jobs.

Unlike in other parts of the world, where renewable energy capacity is replacing conventional power capacity, India's renewable energy targets are additional to existing capacity. This makes the job creation benefit even more pronounced as all the jobs created are new and additional jobs. Furthermore, with the exception of rooftop solar, most of India's renewable energy capacity is added in non-metropolitan regions. This creates an active ecosystem of employment without further burdening the resources of metropolis regions. In order for India to skill up to reach the scale of its ambition, cooperation on skill development is becoming imperative. While there is no current bilateral or multilateral renewable energy skilling focused partnership, there are several industry associations that allow for lessons from more advanced renewable energy economies to be transferred and adapted to the Indian context. The International Solar Alliance, led by India and France, also identifies capacity building as an important function for itself in its aim to facilitate the scaling up of renewable energy in India. Just as technical assistance and skill development has been central to the overseas development assistance offered by the developed world, capacity building for renewable energy deployment is likely to gain focus in the coming years.

Existing USAID, DfiD and GIZ programs are already beginning to direct some attention towards building capacity both through skill development, as well as in the form of regulatory capacity to govern renewable energy supply.

8.3.3.3 Climate Change

Climate change will play an important role in shaping the evolution of India's economy and energy sector. Depending on the level of emissions, projections of global temperature rising above pre-industrial levels between 2C and 4C by the century's end could lead to severe impacts on water, food, coastal flooding, heat stress and health impacts—as well as systemic impacts on international security. The choices India makes and the pace of shifting to a lower carbon economic pathway will play an important role in determining the environmental sustainability of its economic and energy growth.

In 2011, India was the second most vulnerable country in the world on an index of vulnerability (Verisk Maplecroft 2011). More recent studies find severe potential impacts of climate change on heat stress and human health (raising demand for air conditioning), food stress, water stress, river flooding, coastal flooding and infrastructure risks (King et al. 2015). The systemic consequences and security risks of such events occurring on a regular basis are of great concern. Shocks to global and domestic food production can result in food export restrictions and contribute, as has happened in the recent past, to unrest, conflict and state fragility. Extreme water stress and competition for productive land could both become sources of conflict between communities. The limited ambitions of China, the European Union and the United States in limiting their greenhouse gas emissions have constrained the available carbon space for countries like India. It is compelled to make choices about its energy investments after recognizing the consequences of global average temperature rise crossing the threshold of 2C—the international consensus among negotiating countries in the global climate regime.

In addition to the climate impacts and risk that India is already facing, there is strong and sustained focus from the international community to act on climate change and constructively engage in the climate negotiations, a role India has only recently begun to play. While India has been branded obstructionist in the past, its stance in such fora is based on the principle of common but differentiated responsibility (CBDR) enshrined in the United Nations Framework of Convention on Climate Change (UNFCCC). India's per capita emissions remain significantly lower than that of other major climate polluters at 1.7 tons against China's 6.2 tons in 2010. Its aggregate emissions stand at 6%, nearly half those of the EU (11%) and markedly lower than those of the United States (16%) and China (23%). However, as it continues to be the world's third largest member state emitter of greenhouse gases, and one that is highly vulnerable to the impact of climate change, India has now put in place a broad range of policy initiatives to tackle climate change. These policies, both ongoing and planned, seek to both mitigate and adapt to the impacts of climate change. The initiatives span several sectors, technologies and levels of intervention. India's intended nationally determined contributions (INDC) highlights three clear targets for 2030. One is to reduce emissions intensity of GDP by 33–35% from 2005 levels. The second is increasing the share of non-fossil electricity generating systems to 40% of the commutative installed capacity. The third target specifies the creation of additional carbon sinks of 2.5–3 billion tons of carbon dioxide equivalent through additional forest and tree cover (Ghosh and Chawla 2015).

India's INDC further expands on its already aggressive renewable energy and non-fossil energy targets. A 40% non-fossil electricity capacity would mean a four-fold increase in absolute terms over today's installed capacity. This poses a significant demand in terms of finance and a significant challenge in terms of engineering. India's current non-fossil fuel capacity stands at 97.5 GW (50 GW of renewable energy, 5.5 GW of nuclear and 42 GW of large hydropower). This implies that of the current total capacity of 302 GW, non-fossil fuels contribute close to 30%. The INDC target of 40% non-fossil fuel capacity by 2030 would require India to have close to 320 GW of collective renewable energy, nuclear and large hydropower capacity. As India's total electricity capacity grows less than three times between now and 2030, the non-fossil fuel capacity would have to quadruple to reach the target of 40% share. This capacity target would result in 30% of electricity generation coming from non-fossil fuel sources by 2030, nearly double the share of non-fossil fuels in the current final electricity consumption (Ghosh and Chawla 2015).

Despite India stepping up to the plate with its detailed plans and actions on climate change, an important foreign policy debate continues to brew on India's stance on equity and common but differentiated responsibility in international climate negotiations. One possibility, in the run up to 2020 when the Paris Agreement comes into force could see India making the ratcheting up its commitments, or even the realization of its NDC, contingent on available financing, appropriate technology learning curves and dissemination, and a global carbon price. Moreover, India could further its discourse on sustainable lifestyles into action by promoting differentiated responsibility within the country (say, higher carbon tax on large point sources or on luxury emissions, such as purchase of diesel sports utility vehicles). This would be more equitable than coal cess, India's pioneering policy in this area.

As a result of its growing vulnerability to climate risk, as well as international diplomatic pressure, a new India has emerged in the global climate discourse. Backed by its large renewable energy targets, India has committed to be a climate leader in a world of diminishing ambition on climate action.

8.3.3.4 Energy Security

India is moving from being an energy island to a major player, fully integrated into the global energy markets. Even with fairly significant energy efficiency assumptions in energy demand estimates, India's total primary energy demand is projected across various studies and scenarios to increase between 2.2 and 5.3 times by 2050, a minimum increase of 40–60 million tons of oil equivalent (mtoe) a year. Moreover, with the current substitution possibilities across end-use sectors, and the limits to immediate scale-ups, all projections point to the continuing presence of fossil fuels in the primary energy mix with a growing share of renewable energy.

The Indian government is deeply concerned about the rising share of crude oil imports, from 65% of oil demand in 2000, to 83% in 2013–14 and to 90% in 2030. Coal imports have also been rising year on year, reaching over 20% of demand. By 2030, imports of natural gas are likely to rise to five times the level in 2013–14. Given these realities, energy security has become one of the primary economic imperatives for the world's fastest growing emerging economy. While India is attempting to safeguard its national interests by significantly scaling up its renewable energy ambition, renewables alone cannot substitute for the full range of energy services that fossil fuels provide, in the near or medium term. But from an energy security perspective, renewable energy is attractive as one critical part of a diversified energy mix, one that does not increase dependence on overseas energy sources.

Consider Tamil Nadu, the state with the highest wind power capacity. While thermal power plants provide baseload electricity, small changes are visible during the morning and evening peak power periods. Wind energy lowers the plant load factors of thermal power station during these peak periods and the evidence of lower power outages during these times indicates that wind power is able to provide for domestic and industrial demand across the state (Ganesan et al. 2014b).

Until recently, India's energy supply was inadequate to meet demand, however, overseas energy security was not the primary concern. Domestically produced coal was the mainstay of the modern energy sector, fueling electricity and large industry. India was, of course, dependent on imports of oil (and to a much smaller extent, gas, which was first imported in 2004). Major episodes in West Asia have affected India's economy, among them, the 1979 oil shock triggered a decade of macroeconomic pressure, with oil price fluctuations combining with rising debt service obligations. The 1990–1991 Gulf crisis imposed severe pressure on the balance of payments, eventually resulting in the rupee devaluation in July 1991 and the crisis-driven onset of economic reforms (Ghosh 2006). The US cruise missile strike on Iraq in 1996 again led to crude supply disruptions in India, in turn tripling its current account deficit. India's energy-related crises, in other words, had clear macroeconomic implications for a small and vulnerable economy dependent on oil imports. This is different from the quantity-focused supply-related security concerns of today.

India's response to such price volatility was securing long-term contracts with a few key oil exporters, but that approach is becoming less tenable. Oil (and increasingly gas and coal) are no longer merely macroeconomic variables that require balancing. With a much larger economy now, India's energy security is also intimately linked to actual barrels of oil equivalent being available to sustain industrial and overall economic growth. This lesson became abundantly clear during the sanctions on Iran, when India was forced to reduce cheap imports from that country by 38%.

India's energy demand is no longer marginal in global energy markets. It is the world's fifth largest producer of electricity, the second largest importer of coal, the world's fourth largest consumer of oil (3.73 million barrels a day) and the 11th largest natural gas consumer with potentially much greater demand in future (it currently imports one-third of its natural gas consumption) (British Petroleum 2015). Energy security for India, then, is broader than merely reliable access to resources at a reasonable cost. Instead, a more appropriate definition would be the availability of adequate quantities of critical resources, at prices that are affordable and predictable, with minimum risk of supply disruptions, to ensure sustainability for the environment and future generations. Energy security, then, is not the same as energy independence. India will not be energy secure by pursuing an autarkic policy. Instead, it is working to build the required infrastructure, financial, diplomatic, military and technical capacity as its domestic energy system interacts more closely—in both directions—with global energy markets.

8.3.4 India's Policy Apparatus and Its Impact

India's political motivation to transition to an energy future with a growing proportion of renewables is being put into action by a complex policy and regulatory apparatus. Exogenous factors such as electoral priorities under a complex federal system often serve to make the coordination and cooperation between the governments at the states and center level fragile. This is especially pronounced in the energy sector as energy generation, distribution, and transmission, while deeply enmeshed, are managed separately. This, combined with the political considerations on energy planning (as discussed in the drivers section above) and tariff regulation, distorts efficient market operations. Much of the energy sector in India is state-owned and tightly regulated.

Despite economy-wide market reforms in the early 1990s, electricity reforms in India have lagged behind considerably. The central government passed the Electricity Act in 2003 but its enforcement has remained poor in areas such as enabling open access, governing cross subsidy charges, and regulating tariff reform (Ministry of Finance 2016). Distribution companies (DISCOMs) have systematically introduced price and non-price barriers to further discourage open access adoption. Cross subsidy charges have also remained high, putting undue burden on industries and commercial entities and further disincentivizing industrial activity in the country (Ministry of Finance 2016). The complexities and absence of the enforcement of laws in the sector make it unattractive for foreign investment.

Majority of the transmission network in India is state-owned and controlled by various State transmission companies (TRANSCOs) and the Power Grid Corporation of India Limited (PGCIL) at the state and central level respectively.

The TRANSCOs are guaranteed a level of return on their investments in transmission infrastructure but state owned DISCOMs are highly regulated, and do not enjoy any autonomy on tariff setting. State electricity commissions regulate the retail tariff charged by the DISCOMs and are not allowed to pass on the complete cost of procurement, due to electoral and political compulsions. Due to this below cost recovery, the DISCOMs have accumulated large amounts of debt. This has deteriorated the financial health of the DISCOMs, and has had serious implications for independent power producers who, after navigating the risk in the pre-production construction stage, are faced with risks on payment recovery. As India looks to increase power generation capacity, domestic and foreign private capital will play an important role in the cost and pace at which this capacity is deployed. The risks plaguing the sector make it unattractive for foreign investment, even as foreign investment, in principle, could offer preferential terms for power producers. These risks and their impact are especially pronounced for the renewable energy sector, where most of the capacity is installed by private generators (Ministry of Finance 2016).

As India has seen record capacity additions in renewable energy across the country, especially in areas with high renewables potential, there has been sustained and exceptional coordination and cooperation between the center and the state governments. The successful implementation of solar parks is one such example of the benefits that accrue from coordinated and focused design and implementation of policies. The policy to allow foreign direct investment in renewable energy combined with successful implementation of single window clearances, easy land acquisition, and availability of evacuation infrastructure in solar parks have resulted in lowering of the solar electricity tariffs for DISCOMs and the end consumers. The coordinated action on parks has resulted in lower risks for power producers, which in turn has resulted in the flow of foreign capital, as well as foreign companies setting up assets in such locations. This scheme has been so successful that the central government doubled the capacity allocation for solar parks from 20 to 40 GW (Press Information Bureau 2017).

With states and center recognizing the growing adverse impact of the financial solvency concerns of DISCOMs, a recent financial restructuring program titled the Ujwal DISCOM Assurance Yojana (UDAY) has been initiated to alleviate the risks for both power producers who are facing payment delays and defaults, and the financiers financing both the DISCOMs and the power producers. The UDAY scheme is essentially a financial restructuring package that down a roadmap for states to take the DISCOM's debt on their balance sheet in a phased manner. In addition it works on improving on the operational metrics such as the aggregate technical & commercial (AT&C) and transmission losses, as well as the gap between average revenue realized and average cost of supply. As many as 22 of India's 29 states have joined the UDAY scheme so far. It has been accepted by state governments across political lines, irrespective of the political party in power (Ministry of Power 2017). This is indicative of the commitment, across levels of governance, on the need and acceptability of well-balanced and transformative policies. While the full impact of the UDAY program remains to be seen, the roll out of the project has been met with enthusiasm from investors and power producers both within and outside the country. Additionally, several international development agencies are supporting the technological upgradation of the grid and the associated policy enforcement issues. These include the World Bank, GIZ, KfW, and the ADB.

However, other areas of concern in the center-state coordination continue to persist. The Central government has mandated states to buy a specific portion of their total final energy consumption from renewable energy sources. These Renewable Purchase Obligations (RPO) were intended to guarantee continued renewable energy demand in the future. However, there is serious lack of enforcement of these regulations. In early February last year, the central government increased the RPO significantly, from 11.5% in 2016–17 to 17% of generation capacity by 2018–19 along with a specific solar RPO of 8% of generation capacity by 2022 (Tongia 2016). The past record of states on compliance and the absence of any penalty in the case of non-compliance is not assuring for market participants. This has resulted in a failure of the renewable energy certificates market, and further signaled policy uncertainty to the renewable energy market as a whole.

States have often criticized the top-down approach of the national government, especially on the development of new policies and targets without consultations with state governments (Deccan Chronicle 2016). The other and more important reason for the states (or, DISCOMs) not to comply with the central government guidelines is the economics of renewable energy sources. Increase in RPOs as per the guidelines could translate into a higher burden on the DISCOMs. However, with electricity from renewable energy sources such as wind and solar becoming more competitive, state compliance could increase in the future. Additionally, interest from foreign investors in India's renewable energy markets further incentivizes states and DISCOMs to become competitive in order to attract investment into their states.

With increasing contribution of renewable energy to overall generation, grid stabilization assumes importance and needs to be addressed. Flexible sources of generation or electrical storage technologies are not in the portfolio of options available in India today. For this reason, the development of an ancillary services market (frequencies support, voltage control, peaking/operating reserve) must be a priority. A mature market for these services is a prerequisite for the successful integration of renewable-based generation.

In addition to these "hard" infrastructure choices, there are also some critical elements of "soft" infrastructure, which would apply irrespective of the technologies and designs chosen. The design of legislation is of particular importance and cascades down the value chain. For instance, regulations affecting pipeline construction could have an impact on fuels chosen for new power plants. Further, the government's role will expand but in the form of a facilitator through better regulation (including the autonomy and authority of regulators) and protecting the sanctity of contracts, so that long-term infrastructure investment plans can be made with minimal risk premiums imposed on the costs.

8.3.4.1 Need of More Inter-Ministerial Coordination at All Levels of Governance

While a lot has been achieved in the renewable energy generation space, huge strides need to be taken in order to resolve inter-ministerial conflicts. Setting up utility scale renewable energy capacity in a non-park (no government allotted land) area requires immense coordination between ministries such as Ministry of Power (MoP), Ministry of New and Renewable energy (MNRE), Ministry of Finance (MoF), etc. For example, the Central Electricity Authority (CEA), an entity under the Ministry of Power, is in charge of coming out with electricity demand projections for the next five years for the entire country, whereas the MNRE (or, its equivalent at state level) comes out with renewable energy capacity and generation targets. The institutional information sharing mechanism between the two ministries is required to be robust so that generation and transmission capacity is in line with the demand projections in the country.

As long as market-oriented reforms do not take place in this sector, the ministries responsible for overseeing these sectors need to work together to gauge market sentiment as closely as possible. Absence of such a mechanism could easily turn transmission and generation assets non-productive. A recent report by the CEA shows that plant load factor of thermal plants would fall to 48% by 2022, primarily due to the energy efficiency initiatives, low demand, and higher share of 'must-run' (cannot be curtailed) renewable sources (Sengupta 2016). This has serious impact on India's domestic and foreign policy positions. At the diplomatic and economic level, the country's aggressive moves to attract investment into the energy sector are met with luke-warm response due to the systemic flaws in the management of the energy system. Despite India offering the largest developing renewable energy market, the lack of ease of doing business and law enforcement concerns keep investors out.

8.4 Implications of India Being a Swing Player

Energy strategies are central to a country's foreign policy, and as India's energy strategies and priorities evolve, the impact on its foreign policy is imminent. This section focuses on the interlinkages between India's rising renewable energy capacity and ambition, and its geopolitical and diplomatic choices.

The scale of evolution in India's energy sector in the coming decades will be mammoth. It's power system needs to almost quadruple in size by 2040 to catch up and keep pace with electricity demand that - boosted by rising incomes and new connections to the grid - increases at almost 5% per year (IEA 2015). Considering the population growth and the high policy priority to achieve universal electricity access, India is likely to add nearly 600 million new electricity consumers by 2040 (IEA 2015). The IEA also estimates, in line with domestic India estimates, that over 50% of new generation capacity to 2040 is likely to come from renewable and nuclear sources of power, even as new coal-fired plants in India would represent nearly half of the net coal capacity added worldwide. Given the prevailing uncertainty over the pace at which new large hydro dams and nuclear capacity will be built, there is likely to be strong reliance on solar and wind power to deliver on the pledge to build up a 40% share of non-fossil fuel capacity in India's power sector by 2030.

As renewable energy becomes a new and important agenda item in India's energy diplomacy, its influence extends beyond the environmental, and into the economic, social, political, bureaucratic, legal, technological, and behavioral priorities of the country. This has resulted in a new energy security paradigm for India, one in which renewable energy is seen as secure but not sufficient. It is also a paradigm in which India plays the role of a climate leader, and Indian foreign policy must position India as so. However, such a paradigm also places India at the center of a rapidly evolving international political economy of renewable energy, where domestic priorities and international pressures, similar to those faced in the context of conventional fuels, will need to be managed.

8.4.1 Energy Security, not Independence

Energy security for India is not the same as energy independence. Faced with energy security concerns that are deeply interlinked with its foreign policy, India needs to diversify (on the supply side), focus on efficiency and conservation (on the demand side) and on sustainability (on the environmental front). In other words, energy security for India is broader than merely reliable access to resources at a reasonable cost. Its definition should not be limited to quantities and prices. Instead, a more appropriate definition would be the availability of adequate quantities of critical resources, at prices that are affordable and predictable, with minimum risk of supply disruptions, to ensure sustainability for the environment and future generations (Bery et al. 2017).

As India pursues its strategy to acquire overseas oil and gas assets, it has to navigate carefully as it operates in politically fragile states and regions such as Iran, Iraq, Kazakhstan, Libya, Nigeria, South Sudan and Venezuela. In these territories tensions are greater when interests overlap and conflict. Joint investments with Vietnam for oil exploration in the South China Sea have created tensions with China (Bery et al. 2017). It is for such reasons that the government exercises tight control over overseas investments of Indian public sector oil and gas companies. However, Indian firms will need greater financial powers backed by diplomatic and military resources to reduce their risk exposure in less stable areas. In Kazakhstan and Venezuela, China has used the loan-for-oil and loan-for-gas routes for securing long-term supplies. It is unclear whether similar arrangements would be the best use of India's resources.

More than overseas acreages, a crucial aspect of energy security for India will be to avoid disruptions in the transportation of energy resources. It matters little who owns the oil fields, gas wells and coal mines if resources are held up by poor transport infrastructure or geopolitical tensions. Transport blockages could occur on home soil as well. However, in the foreign policy context two key vulnerabilities largely determine whether energy resources headed for Indian shores receive safe passage: control of or access to the shipping fleet, and security threats in the Indian Ocean and South China Sea. Given the global share of India's energy trade, its shipping fleet is extremely small (Ministry of Petroleum and Natural Gas 2014).

India meets one-third of its demand for natural gas through imports, all through the LNG route. India started to import LNG only in 2004. The Shipping Corporation of India is the only Indian company that owns LNG transportation capacity, though in a consortium with Japanese companies. Imports by pipeline are another route for natural gas. For instance, 50% of China's natural gas imports are through pipeline networks. India has also been negotiating or planning for pipelines from Iran (IPI, via Pakistan), Kazakhstan, Myanmar, Russia and Turkmenistan (TAPI, via Afghanistan and Pakistan) (Choudhary 2015). A subsea gas pipeline from Iran and Oman to India has also been under consideration. But geopolitics, security, pricing and operational issues have hindered rollout of any of these projects. However, India's ownership of shipping assets are not necessarily red flags but indications that as India's share in global energy trade increases, its demand for crude and LNG tankers will grow. Indian firms will over time need access to a fleet size sufficient to cover at least 50% of imported energy resources. This will require coordination between ministries and agencies responsible for oil, gas, coal, shipping, ports and commerce and industry. Indian shipbuilding capacity will also have to increase, as would access to finance to place large orders for the fleet.

Even as India builds its own capacity to meet its energy demand in the most efficient manner, it continues to play an important role in forging partnerships to battle security threats that would undoubtedly impact its energy imports. India plays an integral role in providing security in the Indian Ocean, a role it is primed to play as the largest maritime power in the region. With a vast coastline as well as island territories in the Arabian Sea and the Bay of Bengal, India can monitor energy and trade routes better than almost anyone else. It has used this geographical advantage to expand its maritime partnerships with other countries in the region.

In addition, India must build and manage strategic reserves as a part of the overall apparatus needed to integrate more deeply with the global energy system. Some of the risks associated with such deep integration could be eased by increased participation in plurilateral energy regimes. It is not a member of most energy-specific regional organizations. It has only recently become an associated member of the IEA, and is not a member of APEC and its Energy Working Group. However, India will need allies, as has become clear from its recent unsuccessful attempt to join the Nuclear Suppliers Group. This will become an important diplomatic priority in the time to come. It could use the forums that it is a part of, like the G20, to forge close links and add its voice to the conversation.

Looking forward, India's energy related economic and foreign policy priorities must focus on equity investments in energy resources overseas and building a robust renewable energy generation capacity at home. While India's aggressive renewable energy push, if realized, will result in as much as 30% of the total generating capacity to be renewable energy powered, renewables too could add to the energy in-security of the country. Even as the pursuit of energy security acts as a principle driver of energy security, if mismanaged the opportunity posed by renewable energy, could turn into a challenge. DISCOMs continue to be the operative piece of this puzzle. As renewable energy supply continues to grow, risks posed on the off-take of the power from the DISCOM could pose a serious threat to the economy as a whole. Off-take risk has two distinct components, one technical and the other commercial. As the quantum of variable supply grows, technical upgrades and storage/backup options need to keep pace with the growth in renewable energy supply. In the absence of this renewable power produced will face integration constraints, significantly impacting the power producers' viability. Equally, concerns around delays or defaults on payments from DISCOMs and the curtailment of renewable energy supply due to the economic burden that they add to the DISCOMs' balance sheet, could result in further declines in the DISCOMs' financial health. The poor health of utilities could increase the vulnerability of renewable energy power producers, making their business unviable, adversely impacting investors, and leaving the financial sector burdened with non-performing assets.

Nearly at the same time as the announcement of India's increased renewable energy ambition, the government also announced its intention to increase domestic manufacturing. However, the solar industry has not been able to capitalize on the growing opportunity to scale up domestic manufacturing, due to lack of competitiveness with Chinese panels. As much as 90% of the total solar panels deployed in India are imported, with 83.5% of the total panels made in China (Patel 2017). While the declining cost of Chinese panels results in increased competitiveness of solar power, the ramifications of this import dependence has serious balance of payment consequences for India. Going forward, India will have to closely assess the payoff between lower cost of solar power and the increased import dependence on Chinese panels, and the associated energy security impacts. Trading oil imports for solar panel imports would not result in significant gains in India's energy security.

8.4.2 India's Climate Leadership

The Paris Agreement on climate change was momentous for reasons beyond the obvious. There were several tense moments, in the run up to and during the negotiations, suggesting that the expectation of an agreement might have been too optimistic or misguided. However, an agreement was reached, and subsequently ratified and brought into force at record pace. While some concerns persist, including those on ambition, finance, and most recently the commitment of the United States; the spirit of an international agreement on climate change needs to be celebrated. Equally, India's front line role in the process of getting an agreement needs to be acknowledged and understood in relation to its negotiation positions of the past.

In the first two decades of climate negotiations under the UNFCCC, India's stance on Climate Change was one of concern but not one that committed to action. India unflinchingly argued that the onus of action on climate change remained firmly on developed countries, that had, with their historical emissions, caused the largest anthropogenic impact on the climate. Further, India consistently argued that it had other national priorities, including poverty reduction, energy access, industrial growth, etc., that it had to pursue before committing to a cap on emissions. The argument was further bolstered by the fact that India's emissions remained significantly lower than the global average. There was not much sign of movement on this position.

While India had designed domestic policies to tackle climate change, including but not limited to the National Action Plan on Climate Change and the National Solar Mission, it was only in the months leading up to December 2015, and during the negotiations themselves that a new India emerged. Having learned its lessons from failed climate negotiations of the past, India played a positive role even as it defended its long standing position on the principle of equity.

One of the principal points of disagreement between India and the developed world, both in the past but also in Paris, was an attempt to discard the principle of common but differentiated responsibilities (CBDR) enshrined in the UNFCCC charter. However, with the support of like-minded developing countries, India was able to get the agreement to retain the principle of CBDR in the key elements of technology transfer, finance, adaptation and capacity building. However, on other issues it displayed flexibility and commitment to action. India played a constructive role in arguing for ambitious commitments on finance (a floor of under $100 billion), capacity building (including for monitoring and reporting) and technology support (including partnerships) from developed to developing countries.

Beyond the negotiations, India positioned itself as a climate leader by establishing a commitment to renewable energy, in particular solar energy. Together with France, India spearheaded the creation of the International Solar Alliance (ISA). As multiple countries coming together for scaling global solar power production. Through the principle of demand aggregation, ISA could potentially create the conditions for significant decline in solar technology costs, This is what India did domestically with the hugely successful LED procurement and distribution program. ISA is an international organization that brings together countries with rich solar potential (along with solar innovators, developers, and financiers) to aggregate demand for solar energy across member countries, creating a global buyers' market for solar energy, thereby reducing prices, facilitating the deployment of existing solar technologies at scale, and promoting collaborative solar R&D and capacity (Chawla and Ghosh 2016). The International Solar Alliance, now with 25 member countries and growing (ISA n.d.), is a testament of India's growing soft power in the world of climate change and renewable energy.

India also supported the United States Department of Energy led initiative, Mission Innovation (MI). Under MI, member nations agreed to seek to double their respective governmental or state-directed clean energy research and development investment over a five year period. With the change in administration in the Unites

States, commitments under Mission Innovation are unlikely to fructify. But there is a larger implication too. There is a lacuna in international climate leadership, as the United States under the Trump Administration has vacated that seat. Could India, who has been vying for a seat at the top table on climate change, fill that position?

8.4.3 Benign Outcomes

Given the scale of India's clean energy ambition, it has actively sought assistance for electric-transportation, energy storage, grid integration, etc. But, there have been limited (or negligible) transfers in technology and financial assistance. Much of the technology transfer has been limited to knowledge sharing and research, development and demonstration (RD&D) pilot projects. One exception to this otherwise poor record has been the Multilateral Fund (MLF) under the Montreal Protocol. As of November 2010, India has received more than a quarter billion from the MLF to comply with the control measures of the Protocol. Other multilateral climate forums such as UNFCCC, ICAO among others have not seen much action in terms of financial assistance and technology transfer. Additionally, there has been some minimal capacity building assistance under UNFCCC's Climate Technology Center and Network (CTCN), the implementing arm of the technology mechanism.

However, in comparison, India's bilateral cooperation has flourished. One of the most successful bilateral cooperation programs has been with the United States. Many existing sub-programs such as PACE-D and PACE-R, under the flagship Partnership to Advance Clean Energy (PACE), have been expanded to include new work areas such as smart grids and the greening of the grid to ensure smooth integration of renewables into the Indian grid. However, all is not rosy in the India-US relationship on clean energy. Despite many American companies investing and operating in India's renewable energy markets and strong political support for India's renewable energy program, the US and India are fighting several trade dispute cases in the WTO. As the renewable energy market grows, the dissonance between free trade and growth of indigenous industry is likely to keep growing. In the Indian context, this is especially likely to happen as the government focuses on scaling up solar manufacturing under the 'Make in India' program.

Another successful bilateral cooperation has been with the United Kingdom. In the last couple of years, the UK has offered its technical and financial assistance towards reforming India's power sector at state and national levels (GBP 10 million over five years), provided preferential financing to the tune of GBP 200 million to renewable energy and energy efficiency projects in India through the Green Investment Bank (GIB) of the UK, and strengthened the India-UK clean energy research program by increasing its funding levels to GBP 60 million.

There have been similar announcements on cooperation in transportation (modernizing railways) and clean energy (preferential lines of credit extended) with other countries such as Germany, France, etc. as well. While several of these bilateral partnerships on clean energy have been running for multiple years, there is growing trend of closer cooperation, deeper partnership, and increased investment flows. This is a result of the priority received by renewable energy in bilateral government to government meetings, and joint statements.

As the largest economy in the region, India has had long standing cooperation agreements that address geo-strategic concerns in the region. Interestingly, India has extended support to countries such as Bhutan, Nepal and Myanmar in order to support their energy security ambitions. These include the Indo-Bhutan agreement to develop 10,000 MW of hydropower, signed in 2006. Similarly, India and Nepal are formulating a Master Plan for cross-border transmission interconnection for the period until 2035 and an Action Plan on power trade until 2025. These cross-border transmission lines could help India in integrating the mammoth share of renewables that it intends to build in the coming years. These initiatives could do for India what a single European grid did to balance the renewable energy being integrated into the German grid. Looking ahead, in order to avoid conflicts arising from rising energy demand and a changing energy paradigm, it would be worthwhile for India to consider stronger regional partnerships on renewable energy generation, transmission, integration, distribution and manufacturing.

8.5 Conclusion

India needs an integrated, stable and consistent energy policy to pursue its long-term vision. For several reasons both current and emerging, renewable energy is at the heart of this long-term vision on India's energy future. Despite the existing concerns around energy storage, grid stability and integration, and the cost of finance for renewable energy projects, existing, planned, and new initiatives are aimed at addressing these concerns. Building on some of the early wins of the sector, specifically those on market design to bring down tariffs and socio-economic value creation, the dynamism currently being displayed in the market needs to be maintained and further encouraged with policy mechanisms.

As policies address links between demand and supply among the energy sectors and among the economy's non-energy sectors, they should also fully reflect the relative costs of alternative energy choices for consumers. Domestic and foreign policies should be in sync across the economy, in order to facilitate smooth transitions to new energy markets, and ensure a good investment climate with clear long-term direction for stakeholders. Overall policy and regulatory systems must be coordinated, in order to build trust and so that they can take tough decisions to reconcile often-conflicting challenges. This includes, clear pathways to address imminent issues like technology traps, clean energy trade disputes, access to materials, and potential increases in energy insecurity with rising import dependence linked to the renewable energy transition.

As India becomes the largest and one of the most dynamic market places for renewable energy in the world, it will need to remember the drivers of the market—energy access, job creation, climate change, and energy security. The success of the sector will hinge on the ability of renewable energy to respond to each of these drivers. Further, the tradeoff between domestic manufacturing of renewable energy technology and the cost competitiveness of renewable energy technology will also need to be addressed and understood holistically. This is central to understanding the geopolitics of renewable energy from an Indian perspective. The role India plays in the international regime of renewable energy will evolve continuously and influence India's foreign policy, but will also be impacted significantly by the kind of foreign policy choices the country makes in the coming years.

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Part III

Infrastructure Developments and Governance Responses

Chapter 9
New Governance Challenges and Conflicts of the Energy Transition: Renewable Electricity Generation and Transmission as Contested Socio-technical Options

Fritz Reusswig, Nadejda Komendantova and Antonella Battaglini

9.1 Introduction

Countries around the world are currently going through an energy transition. In Europe this implies the move from large-scale electricity generation based to a great extent on imported fossil fuels to renewable, mostly locally available energy sources. The exact structure or design of this transition remains open and contested, however. This energy transition is mainly driven by two policy goals: the massive reduction of greenhouse gas emissions according to national and international climate policy regimes, and national and European energy security goals.

The UNFCCC Paris Agreement (enforced in November 2016) limits the acceptable degree of global warming to 1.5–2 °C. This internationally binding goal implies a reduction of global GHG emissions by at least 80% until 2050 compared to 1990 (Kunreuther et al. 2014; GEA 2012; COM 2014). The almost complete decarbonisation of the world economy has clear implications for the European power sector and by itself asks for a massive increase in renewable energy sources (RES). These ambitious climate policy goals are reinforced by energy security goals, leading to a shift away from imported fossil fuel sources, especially from politically 'instable' regions, mainly towards domestically available renewable

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energy sources. In addition to their regional/local availability, these sources offer the advantage of affordable costs, at least in the middle term (Yergin 2006).[1]

While climate and energy security goals drive the rise of renewable energy sources (RES), it is by no means clear what exactly will be the sustainable energy system structure of the future, and how the transition process to this sustainable structure will be managed and governed. The European electricity system that has evolved roughly during the past century is mainly coined by centralized structures of generation and distribution, together with a decentralized landscape of electricity consumption, embedded into a favourable setting of political and jurisdictional institutions at national and European levels. Other than fossil fuel based systems, RES based generation and distribution systems offer the *option* of much more decentralized solutions, with major implications for spatial location, cost structures, and revenue distributions. At the same time, RES can also be integrated into the existing, mainly centralized system. So the question arises, how a future electricity system might look like, not only technologically, but also institutionally.

This chapter tries to answer the question of how a sustainable electricity system, coined by a high share of RES, might look like, and what new types of conflicts may rise from this transition process. We will do so by following an idealized—and thus simplified—polarity between a centralized and a decentralized set-up (explained in more detail in Sects. 9.2 and 9.3). We will illustrate the decisions needed and the conflicts involved with case studies from Germany, Austria, and Europe and use China as a non-European reference case (Sect. 9.4).

Together these cases should illustrate a major conclusion of this chapter: While energy systems—for various reasons—need to shift towards RES, this energy transition is a major socio-technical change that involves many frictions and conflicts that need new governance modes. In particular, RES open up the option space along the centralized-decentralized polarity. As we will show in the next sections no simple choice can be made here, but rather new combinations of both options will occur, leading to an energy system pattern of higher complexity than we used to know in the past. Exactly this higher complexity of the future energy system—including the emergence of new types of conflicts—defines the needs for new forms of both private and public governance by adaptive and learning institutions.

9.2 The Electricity System as a Strategic Action Field

The transition towards a RES based system fit to meet the energy security and climate change mitigation goals goes well beyond a simple technological change. We conceive that the emergence of RES at scale will lead to a socio-technological

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[1] Energy security has been -and continues to be-treated as a national objective and priority. In the EU electricity sector efforts to be as much as possible independent from electricity imports have led to massive investments in national generation capacity. Combined with forecasts overstating future demand this policy goal has resulted in substantial overcapacities.

transition process, which will be combined with a major shift in generation and distribution technologies, business models, governance structures, consumption patterns and related values and worldviews. There are examples in history when such phases of comprehensive economic, technological, cultural and political change, largely created by introduction of new technologies, did affect not only individual niches and sectors but also transformed whole societies. During such processes of changing practices, structural change and exogenous tendencies occur in parallel to each other and may sometimes interact so as to produce non-incremental changes in practices and structures (Grin et al. 2010; WBGU 2011). As in other transition processes in history—e.g. the industrial revolution or the abolition of slavery or the on-going digitalisation—the current energy transition does not run 'smoothly', without conflicts, frictions or backlashes. Quite the opposite: given the broadness (domains) and depth (intensity) of required changes, and the future uncertainties involved, the energy transition towards climate-friendly RES is and will continue to be a process charged with alternative interests and visions, leading to many conflicts on its way. And as there is neither perfect foresight nor anything like a 'blueprint' for it, the energy transition is and will continue to be an open search-and-learning-process, a real-world experiment (Gross and Mautz 2015).

The evolution of energy systems from fossil fuel based to renewable energies can be seen as strategic action fields or arenas, where different individual or corporate social actors, endowed with knowledge and values as well as interests and power compete for the understanding of the situation, legitimate action and organizational survival in the future (Fligstein and McAdam 2011, 2012). Strategic action fields can be more or less dynamic or 'settled'. The energy system for example used to be a rather settled action field during the phase of the dominating fossil-nuclear power mix provided by large producers and transmitters that evolved during the 20th century mainly in the USA and Europe (Hughes 1983, 1987). Large providers, usually either state-based or public limited companies, did generate and distribute fossil or nuclear fuel based electricity to households and firms, often in monopolistic market situations. The high energy density of the energy carriers and conversion technologies involved strictly favoured centralised solutions. At the 'rear end' of the power lines one could find end-consumers of electricity, who did not produce but only use electricity, and who did not have to care about it—except for rare moments of larger energy crises during the 1970s/1980s. Similar structures could be found in the gas and fuel sectors.

The few large actors of the strategic action field in that period, e.g. electricity providers, coal, oil and gas companies, nuclear power utilities can be seen as *incumbents*. Incumbents are those actors who wield disproportionate influence within a field and whose interests and views tend to be heavily reflected in the dominant organisation of the strategic action field. Thus, the purposes of the field are shaped to their interests, the positions in the field are defined by their claims on the lion's share of the resources in the field, the rules tend to favour them, and shared meanings tend to legitimate and support their privileged position within the field. One of the reasons for this privileged position is the fact that government actors, who set the rules for the field, have regarded energy provisioning as a key strategic factor, with large players in centralised systems as an option without alternative. In addition, and in part as a consequence of this strategic 'fit' between government expectations and field structures, large energy providers and their lobby groups did have privileged access to decision makers, influencing their views and actions. This not only holds for interests (e.g. sunk costs), but also for worldviews (values and interpretations of facts and trends). For this reason, traditional energy systems display a significant inertia, leading to path dependencies and carbon lock-ins (Unruh 2000; Unruh and Carillo-Hermosilla 2006), i.e. self-reinforcing techno-institutional complexes based on fossil fuels.

With the emergence of RES, the strategic action field has completely changed and has become increasingly dynamic. New technologies with new ownership options, new players and new governance modes have emerged. Today it has become obvious that these options are associated with specific features and related risks and benefits. With respect to the ongoing transition towards a RES a major cleavage both in discourse and in real system design options is the one between established energy technologies and renewable distributed energy resources technologies.

While in reality the option space is slightly more complex and mixed, for reasons of simplicity—and because the energy policy discourse is structured along these poles—we structure the electricity system according to this polarity. The emergence of RES has broadened the option space of the modern energy system: While the conventional system, based on fossil fuels and nuclear power, was large scale and centralized by nature, some RES are very modular and therefore can both be large scale and centralized as well as very small scale—decentralized. Due to RES the energy system of the future thus has the option and opportunity to integrate both dimensions.

At the core of the electricity system are technological or physical system components for the generation, transmission, storage and consumption of electricity. 'Behind' these technologies we find social actors that develop, own or use them, endowed with different interests and worldviews. In any given point of time these actors do hold specific preferences towards a centralised, monopolistic system based on fossil fuel and nuclear or a system which is more fragmented, largely based on renewable sources and complementary technologies.

The energy transition can be described as a move from fossil to renewable generation technologies, and related transmission, storage and use system components (see Fig. 9.1). At the upper ('fossil') end we find conventional coal, oil or gas fired power plants. They are part of a traditionally centralized system structure, mostly run by large corporations. Nuclear power plants are less carbon intensive, however due to the involved physical and financial risks they are the most centralized system components so far. Following Schmid et al. (2017) we assume that owners of conventional and nuclear power plants are incumbents and favour its structure and ownership to remain centralized. The transmission grid (extra-high voltage) is owned and operated by transmission system operators (TSOs) which are responsible for system stability in their respective region. Historically, these

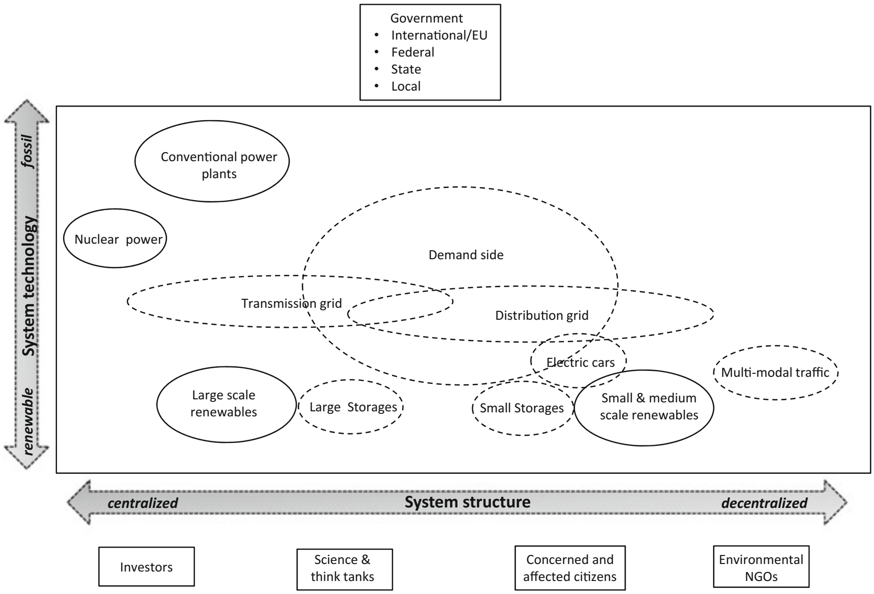

Fig. 9.1 Idealized matrix of the electricity system transition from fossil to renewables (vertical axis) and from centralized to decentralized system structures (horizontal axis). Notes: solid lines = generation; dotted lines = transmission, storage, use

operators emerged from the power plant sector, but have mostly (e.g. in the EU) been separated from it due to market liberalization processes (unbundling). Both for historical and for structural reasons TSOs are incumbent due to their highly regulated and established position, although their role is rapidly changing. We define large-scale renewables as technical devices that generate electricity from renewable energy sources in large quantities per site, typically wind offshore, large onshore wind farms or large photovoltaic (PV) open area parks. Many actors from this field are spin-offs of currently incumbent companies and the general idea of large-scale renewables fits well with existing field rules and ownership structure, at least for the time being.

On the other end of the energy system, we postulate that actors owning small and medium-scale renewables are challengers and require its structure to become decentralized. Small and medium-scale renewables include all technical devices that generate electricity from renewable energy sources in small to medium quantities per site, typically rooftop PV, small to medium-sized onshore wind parks or biomass plants. Their owners often dwell in local or regional proximity and include diverse institutional arrangements ranging from individual households or farmers over collectively organized citizens, e.g. cooperatives, to municipal utilities. Actors from this field are challengers as by the act of generating electricity on the local or regional level they put into question the fundamental field rule that electricity is generated in large-scale units and then distributed hierarchically.

No clear preference with respect to a centralized versus a decentralized structure can be attributed to the demand side, i.e. the sectors agriculture, industry, commercial and service sector, public facilities, private households, and transport. There are some more challenger actors, such as private households preferring green local electricity, or municipal utilities that have the same preference. There is also an increasing number of small and medium size industrial units that are investing in own generation and are slowly shifting their role in the battlefield. However, in the residential sector incumbent basic suppliers currently have market shares of 80% or more. The same openness with respect to the central versus decentral divide holds with respect to storages. Many incumbents hold larger storage capacities, e.g. pumped hydro-storage. Many other storage solutions that would support or complement a decentralized energy system, such as batteries, air pressure or sodium hydrate storage, are still in an early stage of development and penetration.

With the re-emergence of the electric car the electricity system will more and more encompass individual mobility devices which had been external to it due to the coupling of the internal combustion engine to a direct supply with oil products. Electric cars not only consume electricity, they can also serve as storage systems. Their post-fossil potential clearly depends upon the general decarbonisation of the electricity system. Their general fit to a more decentralized energy system will be reinforced if the electric car is not only a substitute for its fossil predecessor.

This core of the electricity system is embedded in a social world of other involved actors that also influence the governance of the system heavily. This clearly holds for the *government* at its various levels: international and national energy and climate change policies, all kinds of electricity market regulation, subsidies for specific technologies, R&D expenditures, incentives, energy fees and taxes, but also process and spatial planning agencies or directives are relevant here. Even at the local level we find governments intervening in the electricity system, e.g. via spatial planning or city owned public utilities. The direction of these various relevant policies with respect to our two axes (fossil/renewable and centralized/decentralized) is not clear or without contradictions yet. This is why we excluded them from the core matrix structure. On the one hand, we find strong government push factors towards decarbonisation (mainly from climate policies). But there are still branches of government or whole governments that favour more or less directly a fossil fuel based energy system. Despite the ambitious climate policy goals of most countries, G-20 countries for example spend more than 440 billion US $ annually as subsidies for fossil fuel production (Bast et al. 2015).

But while governments and electricity system actors are key to the electricity system governance, they do not make it up completely. *Investors* do play a crucial role as well, as they can provide or restrain financial funds for the energy sector.[2] Between 2010 and 2016, for example, investment in renewable energy systems

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[2] As we have included the incumbent players, namely large-scale fossil-nuclear providers, to the energy sector itself (box in Fig. 9.1) we include their substantial investment capacities in the sector. Investors as separate actors outside the energy sector thus mainly include large or small scale providers of funds other than traditional energy providers.

accounted for 230–310 billion US $ annually (including asset finance, venture capital, public markets or government spending) (BNEF 2017, 12; Bloomberg new energy finance's NEO 2017). While fossil fuels in 2016 received a funding of about 100 billion US $, and nuclear power of about 40 billion US $, renewables (excluding large hydro) received about 250 billion US $ (BNEF 2017, 34). This actor group is very heterogeneous, as it includes both small, individual investors (such as self-employed professionals) as well as institutional investors, e.g. pension funds. Most investors, especially large and/or institutionalized ones, are only oriented towards their returns and thus only have secondary preferences according to the centralization/decentralization polarity: they prefer whatever kinds of profits look more promising and low-risks. Some actors though, combining profit orientation with energy-policy preferences, do deliberately invest in small projects, e.g. lean toward the decentralized pole. Moreover, increasingly, institutional investors try to channel investments in decarbonised assets, away from coal.

The second actor group that influences the governance of energy systems are environmental NGOs. This heterogeneous actor group covers local and national actors, but also international organizations, such as *Greenpeace, CAN* (*Climate Action Network*) or *WWF*. Their positions towards energy and climate policies not only influence actors from the energy sector, but also governments and citizens. And of course they influence their members' attitudes and investment behaviours. NGOs have even entered the energy sector directly, e.g. by founding renewable energy supplier firms such as *Greenpeace Energy*[3] or facilitating RES procurements for households and small communities such as the Dutch Natuurenmilieu. Despite their heterogeneity in terms of national/international degree of organization, environmental NGOs in general tend to favour decentralized solutions and position themselves strictly against further fossil—and often nuclear—fuel use.

A third group we see as relevant for energy governance are concerned and affected citizens. According to our view, citizens as consumers are part of the energy system (cf. demand side in Fig. 9.1). Consumers react on signals of price and other product/service or provider specifications. But energy systems in general do also have non-market impacts on citizens, e.g. via the environmental effects of their production or transmission portfolio. According to the environmental preferences of citizens, their attitudes do indirectly (mostly via NGOs or governments) influence the policies of energy providers in the system core. A classical case in point would be nuclear power health and environmental risk assessments of citizens. In countries like Germany a high average risk awareness of citizens (and voters) has substantially contributed to the political phase-out of nuclear power. In other countries, where citizens are less sensitive—and thus governments less pressed—nuclear power is still a rather accepted option in the energy sector (e.g. UK and France among others).

Finally, we would like to mention science and think tanks as governance actors. This is mainly due to the fact that climate change, a major driver of restructuring

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[3] In that case we include NGO-founded actors into the energy sector directly.

energy systems and of RES rollout, is a highly scientifically mediated fact. Not only with respect to climate impact assessments, but also—and primarily—with respect to future mitigation scenarios that need to translate acceptable temperature increase goals (such as 'well beyond two degrees' from the 2015 Paris agreement) into ppm-concentration and then total and annual GHG emission budgets and pathways for technologies. This is a complex challenge that requires interdisciplinary cooperation (e.g. climate science, technological expertise, economics, political science etc.) and transdisciplinary skills (e.g. cooperation with business and political stakeholders). While the science system—not only universities, but mainly extra-university research—has developed these skills, many think tanks do provide related data, scenarios and policy recommendations today. Some of them are funded by industries or NGOs, others are independent, but it is not always easy to figure out to what degree. In any case science and climate/energy policy think tanks provide political actors and the general public with analyses and try to influence government actions—and thus must be counted in as energy governance actors. Their preferences with respect to the two axes chosen are heterogeneous.

9.3 Conflicts and Governance of a Renewable Electricity System

Our general observation so far is that the current energy transition is not only an interest-driven and conflict-prone shift from fossil to renewable sources and technologies, but also confronted with a (stylized) choice between a more centralized and a more decentralized electricity system structure. The option space of a renewable electricity system thus has increased, and the technological possibility of sector coupling (indicated by the electric car) reinforces this opening process (Schäfer et al. 2013). We also see structural path-dependencies, and we see incumbent and challenger actor constellations. This almost automatically leads to the question of adequate governance structures that are able to deal with newly emerging conflicts and a necessary reduction of complexity provided by the new option space (Bernhagen et al. 2015).

The term 'governance' has become very popular since the 1990s, reacting upon the growing complexity of decision making processes in modern societies. Many definitions exist. While more conventional ones see 'governance' as an extension of 'government', e.g. as improved coordination of different branches and levels of government, more innovative ones focus on political decision making in general and see government action as a subfield (Ney 2009). Governance is particularly needed because the new option space of renewable energy systems has led to new conflicts with respect to renewable energy systems (cf. Devine-Wright 2011 in the case of wind). RES introduce new technologies, new ownership structures and business models, RES on average have lower energy densities, thus need to occupy more space, which affects the process of RES planning and implementation procedures. On top of that, the general question of how a new energy system with high

Table 9.1 Facet of governance and typical conflicts

Facet of governance	Typical conflict issues
Technology risks	Technology/risk conflicts, human health and environmental impacts
Ownership structure and payoffs	Distribution of economic and other benefits
Spatial location and identity	Spatial distribution conflicts, regional identity conflicts, landscape aesthetics
Procedures and participation	Participation conflicts, procedural justice
System structure	Centralized/decentralized design, type and side-effects of policies

shares of renewables should look like (system structure) moves from the domain of more or less unquestionable niche development towards a societal mainstream issue. All this has led and will continue to lead to new types of conflicts within the emerging energy system of the future (see Table 9.1).

Although the average environmental impact of individual RES technologies (such as a wind turbine or a solar PV panel) is much lower than the one of an individual coal or nuclear power plant, due to their lower energy density and grid expansion requirements, RES in total need more space and thus affect more landscape 'portions' and more people than conventional plants, especially in visual terms. This leads to new conflicts between citizens (e.g. proponents and opponents of wind farms) as well as between citizens and government bodies and project realizers. So the fact that RES has widened the potential group of concerned and affected citizens leads us to include this latter group into the governance structure of modern energy systems. These local conflicts are, however, by no means confined to purely local issues, such as the spatial location and questions of local/regional identity. Protesters as well as supporters also debate about general technology risks, as well as about the general system structure, especially centralization versus decentralization, and about the adequate policy tools (e.g. whether feed-in tariffs are good or bad in general).

Conflicts are no static features of a socio-technical system, but dynamic events between social actors. In order to better understand the nature of new energy system conflicts, we need to briefly conceive how a stakeholder comes to a certain action and enters the action arena. Interests and worldviews are key for action. We assume that actors formulate their interests according to the asset structure they are endowed with at any moment in time, e.g. oil fields, solar power parks or car manufacturing facilities. But it is important to see that while assets *influence* interests, they do not *determine* them. Actors *evaluate* their assets in the light of current, but especially future *options* for their assets, e.g. in terms of market development, regulatory framework or societal values. This evaluation is thus an *interpretation* of the given asset structure by an individual actor (e.g. a firm), in which societal discourses can and do intervene. It is not assets, but interpreted assets that determine the interests of actors. For that reason, the incumbent

—challenger—structure sketched above is in itself a *dynamic* characteristic of a strategic action field. This can be illustrated with respect to climate change: If anthropogenic climate change is a fact, and if avoiding dangerous climate change is a meaningful or even necessary goal, then the de-carbonization of the global economy has to be the answer. This 'scientific' finding does clearly challenge a range of existing practices, routines, business models, and related policies. It does also devaluate—in a very economic sense—formerly very precious assets, such as coal, oil and gas fields. They turn from private goods to public debts. Owners of fossil based assets now have at least two possibilities: neglect the facts, e.g. by undermining the scientific credibility of the diagnosis—which has been chosen by the US oil and car industries in the 1980s and 1990s (McCright and Dunlap 2003)—or accept the facts and try to re-organize the own product portfolio (e.g. by investing in renewables) or strategy (e.g. by planning to buy renewable portfolios in the future). The point we want to make here is: physical asset structures *as such* do not *determine* interests. Interests arise from *interpreted* assets, i.e. from perceptions and expectations with respect to the physical asset, which again is influenced by public discourses (e.g. science, public opinion). This is an important point with respect to change and transitions: actors do not only change their interests and worldviews once their asset base has changed, they can also change the interpretations of their assets—and thus their interests—in the light of new discourses.

Increasing shares of RES challenges the old system, leading to a transition process. It is important to notice that the RES transition is by no means a 'pre-determined' technological evolution, with quasi-inevitable steps, but a contested shift of the strategic action field. Various factors drive this transition, but in an open, often conflicting manner. Electrification of other sectors such mobility and heating add to the already complex environment while providing clear opportunities to both overcapacity in the short term, and to system stability in the medium to long term. And if actors can change their strategies in the light of new discourses, the incumbent-challenger-divide can also 'migrate' into formerly incumbent actors, e.g. by the conflict between different branches of an energy providers.

In the next section we would like to describe the dynamics of the strategic action field by looking at three examples from cases in Germany and Austria as well as the visionary suggestion of a global grid promoted by the president of the Chinese TSO, State Grid of China Corporation. The following case studies show the need for transparent and inclusive participatory governance process, able to address conflicting opinions, develop compromised solutions and shape discourse and decision making processes.

9.4 RES Conflicts at Different Governance Levels—Four Case Studies

9.4.1 Local and Regional Level—Case of Austria

The "***BESTGRID***" project[4] identified concerns from inhabitants and stakeholders regarding deployment of electricity transmission grids in the UK, Belgium and Germany. Looking at these concerns, Komendantova and Battaglini (2016) identified that they are strongly influenced and related to the decision-making process leading to the identification of the need of the project. The results showed that inhabitants are supporting energy transition but they question the need for large-scale infrastructure like the German SuedLink project in light of perceived or documented available alternatives. In particular for SuedLink local opposition against the project was and continues to be supported by some local governments and some—but not all—local organised civil groups and NGOs. Stakeholders demanded procedural justice such as availability of clear and transparent information and timely engagement of local stakeholders in the decision-making processes. Information should be made available for criteria of assessment of alternative solutions such as underground cable. The affected communities and the organised stakeholders also wished to have a better representation of the impacts of the planned electricity transmission infrastructure, which would go beyond the pure economic assessment.

The BESTGRID project developed and implemented new participatory governance measures. Involved stakeholders and inhabitants evaluated them as positive especially because they provided an opportunity for direct and personal dialogue with employees of the transmission systems company. The most of existing participatory governance measures for stakeholders engagement were at the level of tokenism, including different kinds of information events but any feedback from stakeholders had a consultative and non-obligatory character. Actually, tokenism is the most frequent level of stakeholders' engagement into infrastructure projects necessary for energy transition not only in developed but also in developing countries (Xavier et al. 2017). The BESTGRID project showed that solutions could be found to eliminate or minimize impacts of the grids on human health or environment if a fair and transparent engagement process is on place.

In the "***Linking climate change mitigation, energy security and regional development in climate and energy model regions in Austria***" (LINKS) project[5] concerns from inhabitants and organised stakeholders about energy transition in the Austrian Climate and Energy Model (CEM) regions were identified. The results also showed typical level and forms of inhabitants' engagement into decision-making processes at the local level. The actuality of the project is

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[4] The project was supported by the Intelligent Energy for Europe Program.

[5] The project was supported by the Austrian Climate Research Program.

explained by the ongoing energy transition in Austria, which is reflected in its target to increase the share of renewable energy sources in gross final energy consumption up to 34% by 2020 (National Renewable Energy Action Plan for Austria 2010). This goal, which was settled at the national level, is implemented at the regional level in frames of the CEM regions, some of those are planning to become energy self-sufficient by 2050 based on locally available renewable energy sources.

The CEM Güssing became well-known in Austria and was promoted as a best practice for other Austrian regions and also abroad. The concept of CEM Güssing is based on synergies between energy security, climate change mitigation and socio-economic development strategies, with an assumption to transform the rural region, which was previously poorly structurally developed, to a flourishing region with the help of investment into renewable energy sources and substitution of energy imports. Currently the region is producing all electricity it needs and several small and medium enterprises were deployed in the region to benefit from the available renewable energy. However, the whole model came to jeopardy with cancellation of subsidies leading finally to the defeat of the major, who was a driving force behind the energy transition, at local elections in 2013. One of the reasons for such development was that the CEM model was settled through top-down decision-making process. Inhabitants were hardly involved and did not feel ownership of this model (TERIM 2014).

Bramreiter et al. (2016) conducted cluster analysis of all existing CEMs in Austria and found that all CEMs could be grouped into three clusters: suburban, semi-rural and rural. The majority of CEMs are rural and are located in the East of Austria. Truger et al. (2016) analysed targets of energy security in the implementation concepts of 94 CEM regions. They find that 26% of all CEMs settled a target to become self-sufficient in electricity and heating energy. However, despite efforts from the Austrian government institutions to stimulate measures of participatory governance, the CEM process is still highly centralised top-down process. The stakeholders mapping and analysis of decision-making processes showed that the mayor and the CEM manager are the driving force behind energy transition. However, at the local level there are measures such as energy groups, where all interested inhabitants in cooperation with organised stakeholders can take decisions about application of national funds for different kinds of energy transition projects (Komendantova et al., in review). Even though, there are different participatory governance measures supported by the national and local government, the majority of them are concentrated at the level of providing information and consultation, showing again a certain degree of tokenism. They include different types of public awareness campaigns such as climate cinemas, special programs for elderly people and young people, newsletters and social media reports curing different types of risk perceptions (Riegler et al. 2017). Except energy groups, all other measures raise awareness about energy transition but they don't allow for involvement of feedback from local people nor for their engagement into decision-making processes. Currently engagement of local people mainly take place through different forms of financial participation and engagement in the decision-making process itself takes place only in one CEM, Freistadt, in the framework of energy groups.

The evaluations among stakeholders conducted in frames of the projects described above showed that energy transition is not a conflict-free process and that there are several opinions and conflicts might arise from differences in these opinions regarding future of energy system.

First, several conflicts are appearing regarding the need and the location of necessary for energy transition infrastructure. In the BESTGRID project the need of large-scale transmission lines was questioned in light of available alternatives. In the LINKS project inhabitants did not question the need of energy transition was not questioned but rather the need of energy independence through renewable energy sources was questioned. The government is trying to address this conflict by providing information about the need of infrastructure or transition process but the results from both projects show that this information campaign is still taking place in frames of DAD and NIMBY concepts. Organised stakeholders and laypeople wish to have more information, going beyond simple arguments for the need. They also wish to have more procedural justice by having a chance to participate in the decision-making process and to provide feedback, which will be heard. Energy groups might be a good practice for stakeholders' involvement but further research is necessary on feasibility of such practice.

Second, conflicts are appearing in opinions among decision-makers at the local and national levels when energy transition becomes a topic for political process going beyond discussion about the need of infrastructure. The recent protests in Bavaria against transmission lines, which were driven by local politicians, are an example of such conflicts. Another example is conflicts against around the costs of energy transition and its economic feasibility in the CEM regions in Austria. The CEM Güssing is an example of such conflicts. Also the factors, outlined above, which drive energy transition and factors of traditional energy system put decision-makers under heavy pressure.

Third, there are conflicts among targets of energy security policy settled at the national level and feasibility of its realization at the local level. For instance, review of energy transition concepts of CEM regions in Austria, conducted by Truger et al. (2016) showed the mismatch between goals of energy independence and available in the region resources to reach it. Some of the regions were claiming to reach 100% renewable energy independence target at the same time as their potentials to reach such target for electricity were not exceeding 40%.

9.4.2 National Level—Case of Germany

The German word for energy transition is *Energiewende*. This term has been used by the federal government in order to label a shift in its energy policy after the Fukushima nuclear power plant accident in spring 2011. But both, the term and the action field it refers to, are much older. They date back to the 1970s and 1980s, when the so-called 'energy crises' led to a re-adjustment of the German energy policy. Due to the uncertain provisioning of oil from OPEC countries, first energy saving acts together with a promotion of nuclear power was put in place. Even some large, experimental wind power facilities got funded, but by and large failed due to technocratic over-ambition. It was again a major political factor that triggered major changes in the German energy policy from the late 1980s onward: The nuclear power plant disaster of Chernobyl in spring 1986 popularised the pre-existing anti-nuclear power movement, inspired grassroots initiatives for renewable energy, brought about (and to parliament) a green party, and started to influence the (energy) political sphere. The upcoming climate change debate, brought about by science, reinforced by the mass media, and taken up by politics, strengthened the political relevance of RES. By the early 1990s, these trends had brought about a critical mass of engaged social activists, scientific experts, business stakeholders, and politicians to craft a new law, the Electricity Feed-in Act from 1990, which was the first green electricity feed-in tariff scheme in the world, offering a state-supported market niche for renewables. This law was passed in parliament by a novel coalition of liberals, green and conservative party members, seizing the opportunities offered by the German reunification and the EU attempts to liberalise energy markets of the time (Lüdeke-Freund and Opel 2014). These first attempts to promote RES have then been reinforced by the red-green government in 2000 with the establishment of the renewable energy sources act (EEG—*Erneuerbare Energien Gesetz*) for government established feed-in tariff for the period of 20 years. This federal law was a major change in the action field, as it provided guarantees for RES provisioning, attracting many individual and corporate investors outside the traditional energy sector. Farmers, cooperatives, small-scale private investors could thus be attracted. Even today, the RES sector in Germany is dominated by small-scale owners/investors, mostly due to the incentives given by the 2002 law.

The red-green government also wanted to phase out nuclear power in Germany, and had already passed a law for that purpose. The 2005 elections however brought a conservative-liberal coalition into power, which did away with that law immediately, clearly representing the interests of the incumbents of the action field, owning large shares of nuclear power next to coal. Interestingly, the nuclear accident of Fukushima made exactly this government change its mind within a few months—most probably driven by the fear to lose federal state elections that were due a few months later that year. Chancellor Merkel clearly felt that her own energy policy would not survive a second Chernobyl in the German public. Together with rather ambitious climate policy goals, the planned phase-out of nuclear power until 2022 left the government with a very ambitious energy policy goal, which could only be achieved by a massive growth of renewables. In 1990, 18·9 billion kWh of renewable based electricity have been produced in Germany, mainly from hydroelectric plants. This figure did rise up to 188 billion kWh in 2016, mainly from wind, biomass and solar PV (FMEE 2016). 35% of the installed capacity is owned by private households, 11% by farmers, only 5% by large energy providers. A policy-led change in the incentive structure has thus led to an energy system with a high share of decentralized systems and incumbent actors.

More renewable energy capacity has led to more citizen protests and conflicts, mainly against wind power plants and grid extension. While the acceptance of the

German *Energiewende* by the general public has been and is very high—93% in 2016 support the further expansion of renewables, with support being higher once people have already been living next to e RES device (REN 2017)—local protests have increased in number and intensity. This constellation has led many observers to adopt the so-called NIMBY (Not In My Back Yard) syndrome as an explanatory figure: people protest against a local project due to egoistic motives (health concerns, property devaluation fears etc.), although they in general accept (and profit from) a quasi-public good such as a renewable energy system. Research in many countries has shown that this analytical figure is much too simplistic (cf. Devine-Wright 2011). It misrepresents the motives and discourses of many protest groups, highlighting not only 'egoistic' interests, but also 'altruistic' ones such as nature conservation issues or landscape aesthetic preferences. We also find that criticism with respect to planning and implementation procedures as well as criticisms towards the technological and political design of the energy transition motivate protesters (Reusswig et al. 2016). This not only means that local RES conflicts are conflicts about the correct (local) interpretation of the common good (and not common good versus private interests) (Hoeft et al. 2017), but also that different, sometimes competing views of a sustainable (environmentally friendly, economically feasible and socially just) energy transition are motivating many protests. More recently, right wing populism has grown also in Germany, and a new populist party (AfD) has been successful in entering local and regional parliaments. The AfD is the first party in Germany that rejects the findings on anthropogenic climate change and deliberately is opposing the German *Energiewende* as a whole. Should the party succeed in getting hold of the local protest movements—which is not the case today—local protests will rapidly spread at the national political level.

While both the 2000 feed-in tariff law and the measures taken in the course of the 2011 *Energiewende* had helped to increase the share of renewables significantly in Germany, the government decided to change the policy design in 2014—partly as a reaction to local protests. From then on, tender offers have replaced the feed-in tariff system, with the result that transactions costs for small actors (e.g. citizen associations) have been rising substantially. This policy change is clearly favouring incumbent over challenger actors and will most probably shift the German RES from a more decentralized to a more centralized system. And this in turn will affect local conflicts. Today, in the rhetoric of many protesters, proponents of RES are profit driven outsiders, despite the mentioned real ownership structure valid for Germany so far (cf. Hoeft et al. 2017; Etscheit 2016). In the future, this polemic rhetoric figure might more and more fit to reality. Taken together with the populist claim that 'true alternatives' which have been concealed from the public are in fact available (e.g. dismantling the energy transition towards RES) the future of the German energy system is open in a new sense.

9.4.3 Continental Level—Case of Desertec and the North Sea Grid

In continental Europe there are two areas that have attracted the attention of supporters of renewable energy sources: the sun rich and vast deserts in the south including neighbouring North African countries and the windy North Seas. Over a decade ago, the publication of several studies supported the idea that the cheapest option to decarbonise the European power system is the build-up of a European grid, which stretches also to North African (see Czisch 2005 among others). However, to access the vast resources new cooperation across border needed to be put in place. Desertec Industrial Initiative (DII), a spin off the DESERTEC Foundation, was set up by large and powerful companies as a legal company based in Germany in 2009. DII intended to contribute in creating a suitable investment environment to develop large-scale renewable power in North Africa and related needed interconnection to export part of the generated power to Europe. The economic power and almost unique level of influence of the involved companies gave the impression that a new strong leader was entering the market and it would be able to overcome many hurdles and political barriers present at the time. Things however turned to be rather different and today DII is no longer active in Europe.

The main principle of the Desertec concept was to integrate all renewable energies in a trans-national Supergrid by using a mix of the most efficient and available renewable energy technologies—concentrated solar power in desert areas, wind in coastal areas, hydro in mountainous regions, as well as photovoltaic, biomass and geothermal—in locations where costs could be reduced thanks to the high geographical potentials and to scale. The electricity generated would then be transmitted and traded across regions over several thousand kilometres of distance using HVDC. According to DII, low carbon electricity from the MENA region could provide up to 15% of the European electricity needs. The level of production costs in the MENA region would have outweighs the low transmission losses of HVDC between the MENA region and Europe (Czisch 2005).

Despite the fact that DII still exists as a company today, its focus and shareholders base have changed substantially. Today DII is concentrating in developing RES projects mainly in the Middle East and in some North African countries; the focus on the European market has been abandoned, at least for the time being. There are many reasons for this change and we do not intend to cover them all. The purpose of the DII example in this paper is to stress that regional collaboration is a great opportunity but it is also very difficult to realise. In the special case of DII, concerns about potential European increased dependency on the MENA region as well as the political instability of the region substantially reduced the implementation of projects and the required investments. Moreover, environmental considerations and fairness issues towards the increasing energy need of the MENA region as well as European local RES generators keen to secure their own market shares further contributed to undermine DII objectives.

In the north of Europe, a series of political initiatives aimed at creating the environment suitable for the exploitation of the abundant wind resources. There is no need here to describe the almost two decade long efforts. We want to rather focus on the most recent developments and the ambitious and innovative proposition of TenneT, the Dutch/German TSO, to build energy islands for an optimal exploitation of wind resources.

Offshore wind costs have decreased substantially in the past 2 years with recent bids well below expectations. For example the award price for Germany subsidy-free offshore wind bids in 2017 has been as low as 0.44 Euro cents per KWh.

While this is a very positive trends, it should however not be neglected that grid connection is a costly additional element, which needs to be taken into consideration. TenneT's vision is to create modular islands of a size of circa 6 km^2 where numerous wind farms with roughly cumulated 30 GW capacity can be connected, instead of having each of them being connected to the mainland grid individually. From the islands the electricity could be transmitted over direct current subsea cables to North Sea countries i.e. the Netherlands, the UK, Belgium, Norway, Germany and Denmark. From there thanks to interconnectors and the European electricity market the electricity can flow across the Union and beyond. To realise such projects, collaboration across the North Sea countries is needed as well as harmonised regulatory regimes. Political leadership remains fundamental, in particular in promoting the need to address energy security at regional level, while overcoming national perspectives. Moreover, a strong collaborative process involved all interested stakeholders, designed to identify challenges and develop approaches to remove or mitigate impacts should be put in place. This will contribute to avoid conflicts at a later stage and delay or destroy the options provided by the TenneT proposal. Why did DII fail—or change its design substantially—while the island vision of TenneT looks quite promising so far? We see four interconnected reasons: (1) DII spans regions/countries that are very heterogeneous in their technological and overall developmental levels, while TenneT's energy islands can be built between countries of similar technological and developmental standards. (2) DII's vision included countries from various political backgrounds, while TenneT's project refers to EU member countries as a coherent institutional context. (3) DII was heavily relying on onshore RES in combination with a long distance grid, the need to transit countries with overhead lines without delivering any evident benefit to the potentially directly affected a large number of people, while the TenneT islands operate offshore in combination with subsea cables, affecting much less people directly. (4) Environmental protection is doubtful in several of the countries covered by the DII visions, while TenneT is carefully addressing the environmental concerns of different stakeholder's groups. (5) Burdens and benefits of the DII vision have been distributed rather unevenly, while TenneT's plan includes a rather even burden-benefit sharing between countries.

The planet as a whole is more looking like the DII than the TenneT 'world': uneven or heterogeneous in terms of technology, economic development, political institutions and benefit-creating opportunity structures. What do the success of TenneT and the failure of DII tell us with respect to a future global energy system? Before we try to answer this question we would like to add one more case: China's energy and climate policy and its global grid visions.

9.4.4 Global Level—Case of China's Climate Policy and Its Global Grid Vision

As a huge and economically growing country, China has been grappling with its energy system in general and the extension of its power grid in particular for quite some time. But also in China the transformative power of the two drivers of an energy transition—climate change and energy security—can be felt. China's greenhouse gas emissions, traditionally dominate by coal emissions from electric power plants, have been stagnating or even declining in 2016 for the third year in a row. Observers discuss the possibility that China might have reached its emission peak well before 2030, the year that the Chinese government had promised to do so during the 2009 UNFCCC conference in Copenhagen. China has meanwhile ratified the Paris Agreement on climate change, and its Nationally Determined Contributions (NDCs) include a promise to peak CO_2 emissions latest by 2030 (no new goal, but may be outdated), a share of non-fossil fuels of 20% by 2020, a reduction of the carbon intensity of its economy by 60–65% by 2030 (base year: 2005), and a substantial increase of carbon sinks, mainly due to reforestation (CAT 2017). After US President Trump had announced the intention of his government to withdraw from the Paris Agreement, the Chinese government was among those to complain publicly about this step, arguing in favor of the benefits of both a national and a global de-carbonization of the economy.

A few years back, China operated as a clear incumbent in the energy domain: rejecting any climate change responsibilities as a developing country, and defending its massive use of coal. We would like to briefly note the facets and reasons for this change of policy before we look into the Chinese power grid plans in more detail.

China's cities—home to more than 750 million people—are severely suffering from air pollution, mainly due to coal fired power plants and traffic emissions. According to some reports, 1·6 million people are killed annually due to air pollution. Chinese cities have been among the first political entities to ask for and implement counter measures, with RES as a core option. The negative environmental side-effects of fossil fuel based energy and traffic systems are primarily felt in Chinese cities, affecting the interpretation of their physical asset structure, leading to a re-definition of the public interest.

As part of its industrial modernization strategy, China has built up an impressive technological and industry capacity for RES production. It is home to five of the top six solar panel manufacturers and five of the top 10 wind turbine makers. Chinese investments in RES have been the highest in the world (88 billion US $ in 2016)

(BNEF 2017). The positive economic side-effects of the growing renewable asset structure (RES industrial capacities) is leading to a re-definition of the national interest.

After having experimented with regional emissions trading schemes, the Chinese government is planning to implement a nation-wide carbon trading system later in 2017. While China is not accepting any direct (external) intervention into its climate policy, it has set up regional carbon market experiments and tries to upscale them at a national level.

China is also establishing new financial instruments to finance a low carbon transition, including green bonds markets or a mandatory disclosure of climate-related financial risks.

China is also active in foreign markets, especially in other developing countries in Asia and Africa. In 2016, a record of 32 billion US $ have been invested on renewable projects abroad. This underlines how RES have become part of China's overall strategy to become an industrial leader, challenging others.

While coal is still the dominant energy source in China today, we have seen a rapid upswing of RES and a change in climate and energy policy positions both domestically and at the international level. Other than the US government, the Chinese government seems to believe in the future opportunities of RES, not only for the sake of the global climate, but also for reasons of vulnerability reduction, public health, and industry policy. RES has become an issue of competitiveness in China.

This is also clearly visible in China's recent plans for a global grid. The State Grid Corporation of China's Chairman Mr. Liu Zhenya started to promote the plan of the global grid in his book Global Energy Interconnection (2015). Mr. Zhenya believes that this plan will help to mitigate climate change, to create millions of jobs and to bring peace to the world by 2050. The State Grid Corporation operates the majority of the Chinese grids, including all voltage levels. With more than 1.3 million employees, it is one of the largest employers globally. Following this plan already since 2014, China spent $65 billion on upgrading of its high-voltage lines (Bloomberg new energy finance, 2016).

The global grid vision is to connect different regions with high-voltage direct current (HVDC) and ultra-high-voltage direct current (UHVDC) lines across the world to harness wind from the poles and sun from the deserts. While this global 'masterplan' may sound unrealistic or even presumptuous, the vision behind it is based on realistic technical capabilities and considerations, which make it feasible from a technical point of view.

There are many advantages of this super-global grid vision such as deployment of RES where they are most abundant, optimization of the costs of RES generation and possibility to use the grid to smoothen variability over large distances and dispersed geographical locations. As RES are available at different locations at different periods of the day, the global grid will facilitate electricity to flow day and night independently from local weather conditions. Moreover, HVDC technologies have been increasingly deployed in areas where large generation sites, such as hydroelectrical dams in Africa, are generally located far away from consumption centres. Also direct current (DC) technologies offer technical advantages over the more widely used alternative current (AC) lines. These advantages include low, in comparison to AC, transmission losses over long distance transmission. These DC grids are also known as "supergrids".

Despite its utopic character the global grid vision has potentials to become real. Supporters of large scale RES generation already advocated for building a Supergrid across Europe as an overlay to the existing one. The concept of Supergrid is already known in Europe; it became an important topic in relation to exploitation of wind resources in the North Seas and was strongly pushed by Friends of the Supergrid, an organisation promoting offshore expansion. Moreover, it should be noticed that the majority of cross borders interconnectors are using the HVDC technologies. Also more DC lines will be constructed or upgraded from AC to DC lines to accommodate growing volumes of wind electricity generation. The State Grid Corporation is already bidding for electricity assets, where there are opportunities, to diversify their portfolio. Such acquisition of assets around the globe is a fundamental element to achieve the global grid vision. Cooperation already exists with Italian, Portuguese, Brazilian, Philippines and Australian companies and they are the main shareholders of today's DII.

However, the political feasibility to realize this vision is very difficult. There are several geopolitical hurdles, which are driven by the risk perception of the dominance of China in strategically important critical infrastructure. Attempts of China's investors to purchase critical assets are often seen controversial and not always successful, despite high bids. Moreover, a global grid implies a completely new definition of energy security, which should be achieved in a fair and non-discriminatory way at the global level. The trust required to achieve this new approach to energy security across countries is enormous; it is often conflicting with our history and current political controversies. Even within the European Union and the US energy security remains a national/state objective. Despite existing technical capabilities, it will take decades to develop a new governance framework, which would be needed for such transboundary infrastructure. In Chairman Liu promotion book for this vision he describes that there would be no central power distributing authority but rather an Internet-like smart grid that would distribute power as needed. The question about the financing of the grid also remains open especially in view of the fact that costs allocations may not generally match benefits. Already today public and social opposition for electricity transmission infrastructure is dramatically slowing down realization of projects in Europe as well as in several world regions. Lack of acceptance and related delays are increasingly a global problem, it raise the question about the ability of policy makers to pursue the realization of any mega-large project. While public opposition has become a well-known phenomenon in Europe and in other Western economies and efforts are put in place to deal with it in a constructive and inclusive way, in the rest of the world it is often not understood and usually ignored, thus causing increasing conflicts both at local and national level. Taken into consideration existing fierce opposition on the ground against electricity infrastructure projects, a significant risk exists that severe social and political conflicts may further increase, making the realization of this vision impossible. The fact that the Chinese political system is not well prepared when it comes to deal constructively with civil protest and opposition additionally burdens its capability of designing a global grid.

9.5 Discussion and Conclusion: The SuperSmart-Grid as a Concept to Overcome the Centralised-Decentralised Divide

The emergence of RES has opened up the option space for energy systems—they can become (much) more decentralized in technological and economic terms. Next to technological changes this widening of the energy system option space has been driven by social movements and by regulatory decisions of governments. Today, virtually all countries are more or less intensely confronted with the opportunities and risks of this widened option space. This technological option space is 'populated'—and driven—by energy system actors that follow their interests and worldviews. We have characterized them by using the incumbent-challenger-distinction from the theory of action fields. While many grassroots activists and sympathizing think-tanks clearly favour decentralized solutions with today's challengers as the future incumbents, the traditional large energy providers and still many government actors seem to favour a centralized solution with today's incumbents staying in place. Their willingness and ability to rapidly decarbonize remains doubtful, although some of them have started to diversify their assets and invest heavily in RES, and especially large-scale renewables have experienced a substantial boost under their hands.

Our short digression into the nexus between assets, interpretations and interests has shown that actors can change their interests despite of an unchanged asset structure—just because they interpret the future options of their assets differently due to changed discourses and regulations. This does also hold for nations, as our example of the changing position of China's energy and climate policies should illustrate. The recent slow-down of RES growth in Germany shows, on the other hand, that incumbent actors do still dispose of sufficient power to 'smoothen' or 'stretch' the necessary transition process towards RES. The contrasting fate of DII versus TenneT's energy islands reminds us that a more electrified and renewable energy future needs a careful design of its integrating grid, taking into account the heterogeneity of technologies, institutions, and fair burden sharing.

In order to limit global warming to under 2°, urgent measures are required to move towards low carbon energy generation. This requires a significant acceleration in the growth of RES. Additionally, the goals of European energy security policy require diversification of energy supply, including a greater use of domestic renewable resources that are both decentralised and at scale. In this context, the two goals are strongly related to each other and their success depends on the ability and willingness to pursue them in parallel in a coherent and visionary way. In order to guarantee an efficient, economic and socially acceptable energy transition, the growth of RES will have to include both large and small-scale electricity generation, the use of all distributed resources, and the participation of all interested actors.

In our view, the future of the energy system with respect to its structure will not be one of *either* centralized *or* decentralized. Instead, we will most probably see a mix of both options. Large and small scale renewables are a reality even today, the same holds for storage systems and the distribution of 'prosumers' at the (former) demand side. The very nature of RES allows for a combination of centralized and decentralized systems, according to local energy availability, technology and ownership structures. Accordingly, the incumbent—challenger—dichotomy will be realized in a multitude of energy actors in the field. While centralized fossil actors will—hopefully very rapidly—vanish from the scene, a shift in political regulations and societal discourses will probably have a double effect: (1) Former incumbents will add 'challenger' branches, over time change their views and interests, and at the end of the day shift their asset structure towards RES. (2) New, rather decentralized actors will continue to enter the arena, challenging less the technology but more the business models of the more centralized (former) incumbents. It will heavily depend upon the governance process of the energy transition towards RES to find out whether these changes will happen fast enough compared to climate policy goals.

If our analysis is correct, two trends will become clearly visible in the future: (1) The RES based energy system of the future will be *more*, not less complex than the one we have now. Given the dynamic interplay between assets, interests and worldviews we will probably not witness a simple 'phasing out' of former incumbent actors, but rather their attempt to change their asset structure, may be accompanied by some attempts to slow down processes in order to buy time—time that the climate system may or may not have. In any case the RES action arena will be populated by a heterogeneous mix of actors, leading to more instead of less complexity ad competing interests within single organisations. (2) A second trend that we believe to be obvious is the increase in energy related conflicts in the future. Due to their lower energy density, RES systems and their grid connection will affect more space and people than the fossil-nuclear system of the past. As the NIMBY interpretation falls short in explaining these conflicts, a more even distribution of (monetary) benefits from RES will not be sufficient.

This double diagnosis raises the question: How can a more complex and conflict-prone energy system best be governed?

Purely technological changes will not be sufficient. We have seen that energy conflicts arise from RES systems and related grid extensions. It is not by accident that the Chinese proposition for a global grid does severely underrate this issue—a country where civil protesters are not tolerated can hardly deliver a blueprint for how to deal with growing RES conflicts. But how can it be done then?

Given the heterogeneous reasons for conflicts (cf. Sect. 9.3) one would also have to deal with questions of location and local identity, of procedures and participation, and of societal benefits (payoffs). It is less for egoistic reasons that people protest against wind parks or grid extensions, although they play a role (and should not be blamed, especially in an egoistic society). In their self-perception, protesters act as advocates of the common good—or at least their interpretation of it. We thus need a much more elaborated discourse on the common good and heterogeneous interpretation of it. While many active protesters would not accept personal benefits from a disliked project, the often undecided local majority would appreciate regional benefits—especially in less densely populated, often marginal regions.

In order to meet objections against the fairness of procedures preceding a project approval, we need transparent and fair processes of citizen participation. This has to go beyond existing forms of formal participation which usually come late and get access only to a narrowly defined group of potential opponents. Also the scope of existing procedures needs to be expanded. This requires the establishment of regional and national discourse spaces and professional agencies that can impartially manage such discourses. People should be both invited and empowered to discuss their regional energy futures, the option space and the benefit-burden-sharing associated with it. The more regionally available challenger actors (or regionally active incumbent ones) there are, the higher the probability that local actors are among the beneficiaries of the energy transition.

However we will also need a clear understanding of the democratic character of energy related decisions, i.e. that discourses can be open and long, but decisions have to be taken, they can be taken based on a majority vote (instead of a consensus of all), and that decisions are binding even for opponents—at least for a given period. If designed well, such processes of organizing the energy future at a regional or national scale can be linked together.

The failure of DII as well as the critical aspects of Chinese super grid plans show that a technologically feasible and economically well-calculated global master plan will not be sufficient. We will need a virtually global grid that is able to combine distributed small and large-scale resources and will thus allow the optimisation of the usage of local resources whilst ensuring a secure and flexible electricity system.

Such an integration of RES into the European electricity system—as well the electricity system of any other region—requires the existing grid to be upgraded. This includes new projects and the improvement of existing infrastructure, as well as the deployment of new technologies to increase automation and make the entire system smarter.

Such developments would allow the electricity grid to connect millions of new small generation units to large remote generation and distant load areas to fully satisfy demand independently from local resources and generation capacity. This would enable the decarbonisation across regions in the most economically efficient way.

In order to achieve such efficiencies on the scale required, what we call a SuperSmart-Grid is needed. A Supergrid, which is large enough to connect different world regions via high voltage direct current (HVDC) technologies, will enable access to RES where they are most abundant and to balance variability over large geographies. A Smart grid, supported by digitalised, automated advanced features, intelligent and able to safely integrate millions of small and large prosumers, will enable optimal utilisation of local resources while bringing the safety elements to island the local grid in case of need. When complemented by a favourable market design, existing technologies can deliver the required decarbonisation targets in the electrified system. The technical ability, still to be further developed, to islands grids—and connect them again—will be fundamental to move towards an electricity system which is stretching over continents as promoted by Mr. Liu Zhena. This will provide the security features required to maintain reliability of the system also in case of disruption. Of course, further considerations need to be made with regard to generation strategic reserves.

Such a SuperSmart Grid is a very powerful approach supported by sound ongoing technological development. It will require maintenance, control and inclusion.

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Chapter 10
Connecting Visions of a Future Renewable Energy Grid

Marloes Dignum

10.1 Introduction

Developments towards a renewable energy system are ongoing. Along with these developments, trends and ambitions on different geographical and governance levels are brought together. The European Union has the ambition to cut greenhouse gas emissions by 80–95% by 2050 (EC 2012). The 2009 European Third Energy Package strived for the realisation of a single European energy market.

Combining these developments, a future single EU electricity market should largely be based on renewable energy provision. As the current electricity system is highly dependent on fossil fuels, there are still ample possibilities for the technological and institutional configurations of a future renewable energy system. Energy conservation is an important aspect for realising the 2050 goal (EC 2012). In addition, a renewable energy system towards increasing decentralisation is developing. It combines small-scale production such as local (community) energy and larger scale production through for example offshore wind or utility solar power. The developments indicate that high voltage lanes and the level of solar panels on the roofs of homes are to become part of a single European electricity market. All these segments need to operate together with the current centralized grid that may, or may not, exist in the far future.

Current developments for renewable energy are largely decentralized and develop on a case-by-case basis. These developments occur on an increasingly large scale. If this trend continues, future renewable energy initiatives could increasingly include more characteristics of centralized systems. These large-scale developments include for example offshore wind energy projects and utility solar power. In addition, there are also other potential future technologies that promise a sustainable future energy provision and that are still in the development phase. For

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the centralized option this may be nuclear fusion, and large-scale solar power in desert areas (Desertec) (Lilliestam and Hanger 2016) and for the distributed option this is, for example, blue energy electricity (from mixing salt and fresh water). This creates a range of options for the more, and less, distant future with a large uncertainty regarding the energy supply options. While visions are versatile, some more extreme visions state a (almost) full energy and provision by only one of these options.

The developments of the distributed and more centralized renewable energy system have different actors that guide the development, different localities, and different scopes. Distributed energy currently develops from a spectrum of actors including grassroots developments of local (and often co-owned) solar and wind energy projects and more commercial efforts. Large scale developments, and most notably off-shore wind energy are guided by efforts of the national government. Yet, both developments simultaneously contribute to a future energy system. The question rises to which extent these developments are competing and to which extend they are synergetic. To create insight in this issue, this chapter centres the future visions of different distributed renewable energy systems and maps it against actual developments.

The analysis will focus on current developments in The Netherlands. The Netherlands has the ambition to actively pursue renewable energy development. This requires large efforts as the country is currently in the rear-guard of Europe. Currently, a spectrum of distributed energy initiatives is unfolding in The Netherlands. We zoom into two rather extreme forms that are rapidly growing and can contribute to a distributed energy system: communal energy and offshore wind energy development. This forms a good situation to study the simultaneous development and performativity of a spectrum of visions (see also Sect. 10.4).

For the analysis, the chapter centres the shaping capabilities of future visions and expectations. Visions are seen to guide contemporary developments of establishing a future energy system. This shaping capability is a general property of visions (Brown et al. 2000; Van Lente and Rip 1998; Dignum 2013). By portraying a discursive future image, a vision aligns thinking patterns and can create the possibility for allocating resources towards the envisioned. This is called the performativity of visions.

Section 10.2 forms a theoretical section on vision performativity, which results in the presentation of the analytical framework. Section 10.3 describes the approach. Section 10.4 describes the case study selection. Section 10.5 analyses the selected visions of offshore centralized electricity production and distributed electricity production in local solar and wind energy projects. Attention is paid to the synergy between these visions. Section 10.6 addresses the implications and forms a discussion. Section 10.7 concludes this chapter.

10.2 Vision Performativity and Analysis

This research takes the formative capabilities of visions as a point of departure. Future visions portray an image of the future that is in certain aspects more desirable than the current state in which society functions (Achterhuis 1998). Visions have a reflexive nature towards contemporary society and provide insight in how different constellations of actors depict a desirable future. This image implicitly, or explicitly, incorporates criticism to the way contemporary society functions (Michael 2000). The embedding of visions in current times also implies that visions can change along with new insights (Grin 2000). This reflects the learning that takes place.

The shaping characteristics of visions are often referred to as the cycle of promise and requirement (Van Lente 1993; Borup et al. 2006). The idea of this principle is that visions, and the process of envisioning, align actor thinking and provide possibility to allocate resources towards the envisioned. The allocation of resources is linked to promises that are aimed to realize the envisioned. The allocation of (additional) resources to progress on the envisioned path, creates a cycle of investments, developments, and new promises. This cycle can continue as long as the vision, or an update of the vision, is accepted and people act upon the vision (Van Lente 1993, 2000).

Analytically, two strands of futures research can be distinguished. The first strand is '*looking into the future*' this entails the process of envisioning and the visions that result from this envisioning process (Brown et al. 2000). Second, is '*looking at the future*' which is an analytical perspective focusing on real time activities (Brown et al. 2000). It includes the analysis of the structuration, content, and support of future visions as well as the time-span allocated to activities that are guided by visions (Borup et al. 2006; Van Lente 1993). This research focuses on looking at the real-time activities and the future visions that inspire these developments.

While much of the vision literature focuses on the developments of technological artefacts or technological fields (Van Lente and Rip 1998; Bakker 2011), this research focuses on the materialisation of visions through institutional structures (physically, regulatory, norms/behaviour). Complementarity and/or contestation becomes visible through institutional (mis)alignment. Therefore, this analysis includes the development of the physical and regulatory infrastructure. This chapter follows North (1991) in defining institutions: "*Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights).*" (North 1991, 97). This implies that institutions create the possibility space for new infrastructure developments to occur.

This chapter analyses renewable energy infrastructure development in the Netherlands through the lens of vision performativity. It maps the current developments including the drivers and the vision that are linked to these developments. By zooming into the more extreme types of contemporary performative visions (local community energy and offshore wind energy), the aim is to create insight in the synergy in the spectrum of renewable energy developments.

10.3 Approach

This chapter analyses a selection of visions and actual developments of renewable energy provisions to contrast the elements incorporated in centralized and distributed visions of future renewable energy system and assesses their complementarity.

Emphasis is placed on aggregated visions that represent a wide set of actor perspectives. A first selection was made from scientific papers on regulation and governance, sociotechnical design and/or analysis of future energy systems from the fields of responsible innovation and transition studies. The selection was expanded through snowballing. In the search, emphasis was placed on infrastructure development (both envisioned and realized). The final selection included scientific (overview) articles, EU and Dutch policy reports, scientific and technical working papers.

This chapter assesses the synergy of different renewable energy visions by highlighting infrastructure developments (both regulatory and physical) and the integration of these developments. It provides insight in the institutional development and the spectrum of dilemmas and choices actors face, some of which are largely invisible. The analysis of the development consists of two elements.

First, there is a general analysis that outlines the spectrum of renewable energy visions that currently influence concrete developments. A distinction is made between distributed and centralized systems.

Second, the chapter subsequently zooms in on communal energy and offshore wind visions and developments as these are the more extreme forms of current developments of renewable energy. It includes an analysis of the actor network and the future visions supported by the network. The shaping capabilities of these future visions are assessed by the references made to these visions combined with the actual developments. The actor analysis also includes the problem perception, motivations, and values that impact current developments. The analysis provides a reflection on the actual developments and the vision guiding these developments.

10.4 Case Study Selection

The analysis centres on developments in The Netherlands as a representative case study in which several renewable energy visions reached a level of performativity simultaneously (Yin 2009).

The Netherlands has a history of being guided by energy visions. For example, the transition from coal to gas was completed, with large political commitment, in slightly more than a decade (Correljé and Verbong 2004). Also, in 2006, a vision on Dutch gas market development resulted in a strategy to develop a so-called gas roundabout to continue to play an important role as a gas hub in Europe, and to profit economically, even when its gas reserves become depleted (Harris et al. 2010).

Currently, the Dutch fossil fuel energy system is largely centralized and based on fossil fuels. In 2015, the country generated 39 billion kWh electricity from coal, which represented an increase of 35% compared to the year before (CBS 2016).

In 2015, the country had a renewable energy provision of 5.8%. In 2013 the Dutch government in collaboration with private actors and NGOs agreed on a plan to establish 14% renewable energy in 2020, the so-called *Agreement on Energy for Sustainable Growth*. In 2050, a GHG reduction of 80–95% compared to 1990 is to be realised (SER 2013). Current ambition is placed even higher as in accordance to the 2016 Paris climate agreement, fossil fuel use should be largely eliminated. This hints towards the upper limit of the 80–95% ambition (Ministry of Economic Affairs 2016a, b).

Consequently, it is expected that the renewable energy developments will develop rapidly in the coming years. While near-term developments are ongoing, detailed long-term plans for large scale renewable energy provision are still ill-developed. Both distributed and centralized renewable energy projects are being deployed.

10.5 Visions of Renewable Electricity Systems

To realise the Dutch policy ambitions and the Paris climate agreement, a change towards energy conservation and renewable energy production is needed. The increase in renewable energy implies a trend towards decentralised energy. Even large-scale renewable energy provision through for example offshore wind fields offers a far more decentralized energy supply system compared to gas or coal power plants.[1] This section zooms into the versatility of the emerging renewable electricity systems by focusing on the more extreme forms of renewable electricity generation that become part of a future renewable energy system.

Section 10.5.1 introduces the concept of distributed energy production. It includes a range of communal energy projects, from small-scale energy production that is co-realised by joined local efforts, as well as fully decentralized production. Section 10.5.2 focuses on communal energy visions and current developments. Section 10.5.3 focuses on offshore wind energy visions and current developments.

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[1] When the energy production of the planned 5 Dutch offshore wind parks is compared to the domestic gas consumption, the parks produce 1.5 billion m^3 low caloric gas whereas the domestic low caloric gas consumption is 30 billion m^3 (Ministry of Economic Affairs 2016a, b).

10.5.1 Distributed Renewable Energy Systems

A shift towards renewable energy implies an increase in distributed arrangements of energy. However, the degree of (de)centrality drastically differs between different design options.

A distributed electricity system can be envisioned through combinations of different institutional structures. A general distinction can be made between decentralized and distributed systems. Decentralized systems are autonomous systems that operate without interactions to other units whereas distributed systems have the possibility to interact amongst each other or with the central grid (Alanne and Saari 2006). Consequently, decentralized systems are always distributed systems, but not all distributed systems are decentralized systems (Alanne and Saari 2006). The term distributed system, that is used in this chapter, thus forms a broader concept in which the decentralized, autarkic system is the most extreme form.

The concept of a distributed system is still an umbrella term as it can still be designed with great versatility in design choices. Figure 10.1 provides an example of a distributed system as conceptualized by Alanne and Saari (2006).

This example is a broad schematic representation of distributed energy and gives an impression of the potential spectrum of design choices. For example, the figure does not distinguish between types of energy, alternative storage options, and summer-winter fluctuations in demand and supply. These long-term fluctuations are hard to balance (Orehounig et al. 2014). The domestic focus of this image also raises the issue of energy demand for heating buildings, which is a crucial aspect of the energy demand of the built environment in the Netherlands. Heat demand could be cut through conservation measures such as increased insulation, heat pumps, or solar boilers. These conservation options can each be incorporated in a distributed system. When focusing solely on renewable electricity provision, as is the focus of this chapter, such measures represent a potential reduction of electricity demand.

Local electricity generation in homes is a focal point of Alanne and Saari's (2006) representation of a distributed energy vision. Within this focus, system boundaries, technologies, and infrastructure design choices remain an issue. Four examples are given.

First, the focus on distributed generation in neighbourhoods also implies uncertainty regarding the system boundaries and whether it also includes industry, office spaces, and mobility. These system boundaries are important to assess as well as the extent to which energy provision can be realised through such a system, and whether fluctuations in energy demand and supply can be handled by the distributed system or whether a centralized system remains needed for sectors or parts of society, and who (should) bear(s) the costs of the distributed system and the centralized system. The intensity of use of this neighbourhood system is not addressed and is highly dependent on the design choices and the phase of the transition.

Second, the scale of interaction between this distributed production and centralized (single) energy consumption and distributed entities is variable. Figure 10.1 leaves the character of the single entity unmentioned. It can be an energy

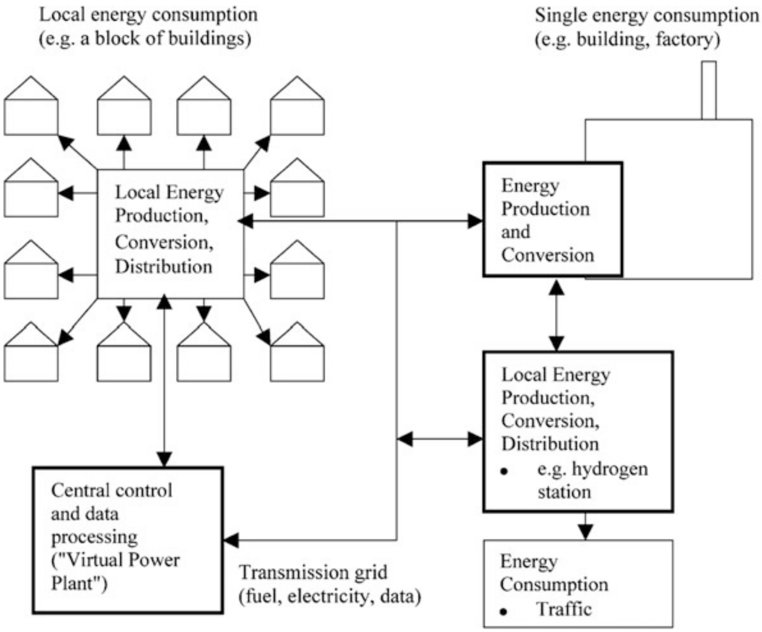

Fig. 10.1 An example of a distributed system. *Source* Alanne and Saari (2006, 544)

consuming factory or a power plant (conventional or renewable). A flexible and stable energy producing facility can serve as a backup system in case distributed production is not equipped for fluctuating supply and demand and can create additional security for electricity provision.

Third electricity storage is not part of our current system. Figure 10.1 addresses potential storage in hydrogen. However, while electricity storage is still difficult, a future system may incorporate storage options such as home batteries, neighbourhood batteries, car batteries of electric vehicles or conversion to gas such as hydrogen. Tests are done with these types of options.

A fourth interesting aspect is the emergence of a central control and data processing plant that balances electricity demand and production. This is a new type of role in the electricity system that emerges with increasing fluctuation in energy provision that coincides renewable production as balancing also needs to occur with centralized production. Trading becomes more frequent as many households and potentially small companies feed electricity into the grid on irregular times.

Along with these design choices, the range of technologies suitable for distributed generation initiatives is expected to increase as new technological options become available. The design choices only increase when more technological and (consequently) more institutional choices become available. These deliberations and design choices play a role in each of the options for distributed system development. We will tune into two more extreme options; communal energy and offshore wind.

10.5.2 Communal Energy Visions and Developments

This section focuses on the visions and developments of communal energy production. In addition to (inter)national renewability ambitions, renewable energy visions on a municipal or regional scale become increasingly prominent (van der Schoor en Scholtens 2015). Networks such as the Covenant of Mayors form a collective of cities that each have ambitious CO_2 emission reduction targets. Also on the level of the community itself, action for reaching renewable energy is increasingly taken. Additionally, property owners can individually arrange energy conservation and production measures, or communities can collectively act to realise communal forms of energy. Taken together, a whole spectrum of possibilities of communal energy emerges.

10.5.2.1 Vision, Actor Network, and Current Development

The contribution of communal energy provision, related to the total amount of energy demand in The Netherlands is small, but the speed of development is high. At the end of 2015, there was an estimated 1515 MW of solar energy and 3391 MW of wind energy generated in The Netherlands (CBS 2017a). A small portion was developed through communal energy project (115 MW wind energy and 23 MWp solar energy) (Schwencke 2016).[2] In 2015, the increase of community wind energy provision was 34 MW. Another 87 MW was planned (Schwencke 2016). In the same period, community solar energy tripled to 23 MWp and was expected to more than double in 2016 (Schwencke 2016). The number of energy cooperatives increased from 262 in 2015 to 313 in 2016 (Schwencke 2016). Also, the scale of the projects becomes larger. On June 18, 2017, a large communal solar energy system with almost 7000 solar panels opened.[3] Although this is about one fifth of the largest commercial solar park in the Netherlands,[4] it illustrates that in the future utility solar power may also be realized through communal energy development.

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[2] Home owners who independently position solar energy on their roofs, are not included. Even though this also increases the trend towards distributed energy.

[3] See http://www.zonnewijdebreda.nl/ (accessed 1 September 2017).

[4] In January 2017 the largest utility solar farm of The Netherlands was located in Delfzijl and counted 120.000 solar panels. https://www.delfzijl.nl/internet/nieuwsberichten_42511/item/grootste-zonnepark-van-nederland-officieel-in-gebruik_88723.html. Accessed 18 June 2017.

The visions of communal energy initiatives drastically vary. The spectrum includes the ambition to mobilise neighbours to install solar panels, to creating a completely energy neutral municipality based on local efforts (van der Schoor and Scholtens 2015) or autarkic visions. Some, of the initiatives depart from the notion that real change is to be developed from bottom-up under pressure based on contextual factors such as climate change that put pressure on current practices (Seyfang and Haxeltine 2012).

The drivers for initiating these projects are quite different compared to conventional energy projects. These initiatives generally share a loose vision to realise renewable energy (van der Schoor and Scholtens 2015). Some of these initiatives focus on the creation of an emission free geographical region and/or want to contribute to a better quality of life. An example of such an initiative is NEWNRG. This private entrepreneurial initiative focuses on achieving a fully local renewable energy provision in the Amsterdam metropolitan area by 2028. It actively stimulates community driven initiatives by bringing together experts, knowledge, and (generating) demand. Van der Schoor et al. (2016, 98) identified three main drivers for communal energy projects: the realisation of sustainability goals, maintaining financial resources in the region, and the democratisation of energy resources. On a higher level of organisation, the level of ambition appears to rise and the vision become more detailed. For example, when the municipality is involved, the vision is more detailed, but citizen involvement becomes reduced (van der Schoor and Scholtens 2015).

In addition to these public actors, communal energy projects are by definition at least partly carried by the local community. The spectrum of community actors involved in these projects is diverse. These can be home owners, but also the active involvement of other organisations such as sports clubs, neighbourhood centres, schools, or grocery stores. Also, professional organisations can be involved, and initiatives can consist of mixes between volunteers and professionals (Geels 2014; Klein and Coffey 2016). Policy and regulations set the conditions for collaboration and the design choices of integrating renewable (small-scale) energy in the current energy system. Pioneering bottom-up initiatives generally operate on a non-commercial basis. The community participation of local communities can increase the support of renewable energy initiatives.

In The Netherlands individual energy initiatives are generally built on the national regulation that assist the small-scale developments of solar panel on residential roofs. Home owners can use the grid as a battery by delivering the solar power generated on their roofs to the grid in times of surplus, and use this power at a random time when they need electricity. However, as electricity is not stored, demand and supply fluctuation needs to be adjusted real time elsewhere. The small-scale generation on roofs is also more expensive than larger scale generation. Therefore, government support for this type of renewable generation is also based on increasing public awareness and acceptance of renewable energy (Ministry of Economic Affairs 2016a, b). The legislation will remain in place until 2020. In addition, the national government published a brochure that helps municipalities to govern local energy initiatives by local actors.[5]

Communal energy initiatives generally focus on wind energy or a solar farm. Most of the (smaller) initiatives tend to focus on the realization of one project at the time. For such a construction, the energy initiative generally operates as a legal entity such as a cooperative. When focusing specifically on these projects, there appears a trend towards larger projects and an increase in projects (Schwencke 2016).

As the number of local energy cooperatives grows, so does their level of organisation. When a communal energy projects materializes, the collaboration also takes the form of a legal entity. These entities often become members of regional, or national cooperatives. Specialised NGOs are emerging in the field for communal energy. For example, in The Netherlands, ODE Decentraal safeguards the interests of cooperatives, HIER Opgewekt collects and disseminates knowledge on communal energy developments, and RESCOOPNL facilitates project realization. These organisations can act as intermediaries that collect and disseminate knowledge.

Often, these cooperatives are rooted at a certain geographical location and focus on realising renewable energy there. This can link up with municipal CO_2 reduction ambitions (Arentsen and Bellekom 2014). Other cooperatives have a national focus (e.g. Windvogel, Qurrent). Local initiatives can also link up together and realise regional energy networks (Van der Schoor et al. 2016). There appears to be an increasing organisation and formalisation.

This diversity of involved actors and ambitions, generates a spectrum of possibilities of distributed energy provision based on different forms of initiation, ownership, and division of profits. Klein and Coffey identify eight forms of community participation of local energy development: Purchasing a private installation; Purchasing electricity; Green planned housing development; Intentional sustainable communities; One time funds; Power Purchase Agreements (PPA), Shared Ownership (Klein and Coffey 2016, 875). The degree of community involvement differs per form. Exclusion of community involvement can enhance public resistance (Devine-Wright 2011).

10.5.2.2 Implications and Reflection

The current increased level of self-organisation facilitates learning, knowledge dissemination, and the identification of best practices. Intermediaries emerge that aggregate knowledge and practices and bring together relevant actors (Dignum,

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[5] This is a publication of the Ministry of Infrastructure and Environment (see: http://www.rwsleefomgeving.nl/publish/pages/98212/gemeente_vol_energie_leidraad_stimuleren_en_faciliteren_van_energieneutraal_wonen_binnen_de_gemeente.pdf. Accessed: September 1, 2017). A similar brochure exists in the USA: Solar Powering Your Community: A Guide for Local Governments, Department of Energy 2011 (Klein and Coffey 2016).

forthcoming). Initiatives like these can make the market more transparent and can help to bring together demand and supply efficiently. It can also help to enhance visibility of the initiative and increase demand.

Visions help in building a local network. These visions extensively vary in level of detail. The enhanced level of structuration coincides with increasing commitment to visions on this higher level of organisation. Actors start to commit and aim for ambitious targets and identify future visions.

While some of these visions are ambitious, there tends to be no detailed plan for their realisation. The strategy centres on one project at the time and quick acceleration. When municipalities, and potentially more embedded actors are involved long-term planning and level of detail increase. Distributed energy development has a largely local dynamic, that builds from local communities strengthened by professional organisations. However, there is little reflection on what this growth implies in relation to systemic change.

More specifically, local energy initiatives operate largely autonomously and have the (legal) space to deliver power to the grid while this grid functions based on a system coordination (Arentsen and Bellekom 2014). The institutional structure and the functioning of the grid is taken as a given within this development whereas there are limits in how much energy fluctuations the grid can handle. In order to cope with increasing fluctuations larger changes to electricity infrastructure and grid operation are needed. Adaptations could include energy storage in electric vehicles, and enhancing high grid responsiveness and capabilities (Battaglini et al. 2009; Kempton and Tomić 2005). If these changes are not made, this will either result in grid instability or result in blocking renewable energy harvest at times of peak provision.

10.5.3 Visions of Offshore Wind Energy and Developments

The Netherlands has excellent conditions for offshore wind energy development (Jacobson et al. 2017). There is a good wind climate, relatively shallow waters, experienced industry, harbor facilities, and supporting facilities (RVO 2015b). Despite these conditions, offshore wind development was relatively modest until 2013. This recently changed and offshore wind development became more intense.

10.5.3.1 Vision, Actor Network, and Current Development

The 2013 *Agreement on Energy for Sustainable Growth* gave a boost to offshore wind development in The Netherlands (SER 2016a). These developments are strongly coordinated by the national government. Guided by the 2013 Energy Agreement, the Dutch government implemented three major policy changes regarding offshore wind development. These measures took effect in 2015–2016 and included: government appointment of zones for competitive tenders in Dutch territorial waters; government responsibility for site surveys; and the appointing of TenneT as an Offshore Transmission System Operator (OTSO) (Van den Akker 2016). The OTSO is responsible for connecting the offshore wind park to the grid connection onshore.

For the period 2015–2023, the operational Dutch offshore wind energy provision was set to grow by 3500–4450 MW. The actual and projected wind energy provision is depicted in Fig. 10.2, indicating that current developments are ahead of schedule. For the period 2024–2030, offshore wind development is expected to proceed at a minimum of 1000 MW annually (Van Nerven et al. 2017). There are spaces allocated in the Dutch territorial waters for these windmills and additional spaces will be developed in the coming years (SER 2016b).

In 2016, a large step was made in the realization of the offshore wind energy ambitions with the opening of wind park Borssele in the Dutch territorial waters, 22 km from the shore (SER 2016b). Upon completion, this offshore wind park was considered a price breakthrough. The tender system, with competition between the bids, helped in achieving this reduction (Ministry of Economic affairs 2016a, b). This cost reduction was perceived as a good indicator for future projects. Based on the success of this project, general enthusiasm was high. The Dutch parliament even requested the expedited development of planned offshore wind parks and the development of additional offshore wind energy projects (Dutch Parliament 2017).

The 2013 Energy Agreement was formed by a coalition with diverse Dutch actors. The agreement gave a boost to offshore wind development in The Netherlands. Also, other North West European countries have favorable wind climates and invest in offshore wind energy.

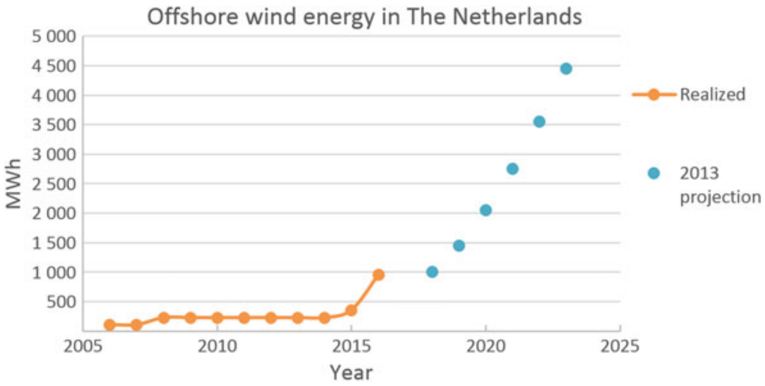

Fig. 10.2 Offshore wind energy in the Netherlands (MWh): realized and projected. *Sources* CBS (2017b), SER (2013)

The industry actors of wind energy development, construction, and substruction are also clearly international. The businesses in the sector represent a mix of incumbent actors (originally from neighboring fields) and new entrants (Wieczorek et al. 2013). The Dutch market actors for specifically offshore construction are strong and operate internationally (e.g. Mammoet, Ballast Nedam, and VanOord (Wieczorek et al. 2013). The development, operation and ownership often lies with large international utility companies such as Dong Energy (DK), Vattenvall, Eneco, RWE, E.on (Wieczorek et al. 2013; RVO 2015a). Development and substruction involves both of incumbent and new entrants (Wieczorek et al. 2013). The combined involvement of established and new firms can serve knowledge cross-fertilization, investment climate, and sector expansion (Wieczorek et al. 2013).

On the level of the grid connection, decisions are more nationally oriented while the entire system has an international nature. The current main system of grid connection is a radial connection in which the offshore wind energy system is connected to the main grid based on distance and grid capacity (Mehos 2016).

In a radial grid design, the connection of wind farms to the shore is provided on an individual basis (EC 2014). The option of a meshed grid forms a coordinated grid connection in which wind farms are connected to offshore hubs, from where connections to various countries are made (EC 2012). See Fig. 10.3.

Compared to a radial grid, a meshed grid reduces the total cable length. It allows easier transport from electricity from coastal sites where electricity is generated to geographical sites where electricity is needed creating some resilience against intermittent fluctuations of energy generation (Mehos 2016). A meshed grid also has flexibility to connect future renewable energy source (e.g. wave or tidal energy or osmotic power) (Mehos 2016) and has less environmental impact (EC 2012). The connection to different coastal sides creates redundancy in case of cable malfunctions (Mehos 2016). However, a meshed grid needs additional coordination and the initial costs are higher. A wide arrange of studies comparing both types of

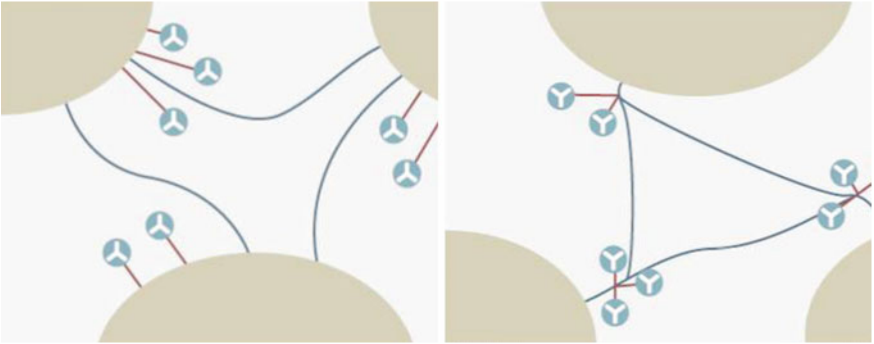

Fig. 10.3 Representation radial grid (left) and meshed grid (right). *Source* NSCOGI (2012, 1–2)

grid connections all conclude that in the long run the advantages of a meshed grid outweigh the disadvantages in comparison to a radial grid (Mehos 2016).

There are also grid structure designs that mix the characteristics of a radial grid and a meshed grid. These designs mix the (dis)advantages of radial and meshed grids (EC 2012).

Currently, near-term offshore wind energy ambitions are high and developments are unfolding rapidly. Experiments of flexible design options for a future meshed grid are encountering financial and legislative difficulties including ambiguous jurisdiction, responsibilities, ownership and distribution on costs and benefits (Mehos 2016). Grid connection to multiple countries raised questions regarding the division of responsibility between Transmission System Operator (TSO), Offshore wind developers, and the national regulator (Müller 2015). This resulted time delays and design adjustments to make the developments more comparable to radial connections (Mehos 2016).

Current developments continue based on radial connections of wind farms (Mehos 2016). Uncertainty regarding the responsibility of operating an international meshed grid and the lack of regional planning prevents potential meshed grid developments (Woolley et al. 2012). The rapid development to EU near-term renewable energy targets stimulate the continued development of radial grid developments (Mehos 2016).

10.5.3.2 Implications and Reflection

Offshore wind energy is being deployed rapidly. The Netherlands has a domestic industry in the field as well as policy commitment and public support. While neighboring countries are also developing offshore wind energy, this development, including grid connection, largely remains a national endeavor. Earlier research indicated that increased internationalization could benefit the innovation system (Wieczorek et al. 2015) and that it would be beneficial to internationally coordinate grid connection as a meshed grid connection has benefits over the current business as usual development (Mehos 2016).

Focusing on The Netherlands, the current developments proceed with high coordination, planning, and facilitation by the Dutch national government. However, these efforts focus primarily on the short and medium term. While there are long-term ambitions there is little attention on the infrastructure implications of such a system. While information is available, institutional barriers and lock-in prevent optimal decision making regarding offshore grid developments, resulting in a suboptimal lock-in position.

10.6 Implications and Discussion

In the Netherlands, distributed energy systems are developing rapidly. While the annual increase in renewable energy rises dramatically, the share is still very modest as Netherlands comes from a very low level of renewable energy provision. Regarding the developments, three observations stand out.

First, the 2013 *Energy agreement for sustainable growth* and the Paris climate agreement shape current developments. The widely accepted 2013 Energy agreement, acts as a performative vision that details the separate segments of renewable energy provision that need to take place by 2023. The 2016 Paris climate agreement creates a sense of urgency to stay at the upper limits of the 2013 energy agreement. This puts speed at the centre of the developments. Considerations of which institutional and infrastructural requirements are needed to support the transition and to maintain energy sustainability, security, and reliability on the long-term attract far less attention.

This is particularly visible in the lack of attention for integrating the centralized, currently dominant, fossil energy grid with the newly developing decentralized renewable grid. The fossil energy supply fosters security of supply as power production can be controlled (and quickly changed in the case of gas). During the energy transition, this existing fossil fuel network can provide backup power in times of high demand and/or limited availability of renewable energy. This is an important option as long as storage of intermittent energy supply for summer and winter variation still needs development.

Second, the system boundaries of current developments are narrowly defined. Local and offshore wind energy developments occur rather isolated. When placing renewable energy developments in an international perspective, it becomes visible that additional international alignment regarding offshore wind energy facilitates a more robust European electricity system. This enhanced robustness on the centralized level could potentially create flexibility for decentralized developments.

However, politically this type of alignment proves far-fetched. The focus on long-term systemic developments and consequently changing international relations and regulations appears to be a road that has too many near-term hurdles to proceed even though the long-term benefits are clear.

This international positioning creates an additional layer to the (de)centralized renewable electricity development. There is the possibility to align both central and decentral visions, but also to align centralized visions internationally. This could contribute to a more efficient and robust future renewable energy system. However, such aligned developments are hardly happening.

Lastly, once renewable energy is installed, it becomes available at near zero marginal costs. Therefore, the pricing system of the backup power, including the infrastructure needed, requires considerations. Policy recognizes that this backup power is likely to come at a relatively high price for these plants to be economically viable (EC 2012). This also implies that when renewable energy provision increases even further, the need for this (backup) power is likely to decline. One could argue that demand is likely to become so infrequent that commercial exploitation becomes difficult or impossible to afford during calamities. Especially, for actors with a financially weaker position society (e.g. civilians). The societal dependence on energy might justify policy involvement here. At the same time, investment in fossil fuels might increasingly evoke public resistance.

A longer-term vision, and more in-depth discussion, on how the *transition* should be taken place instead of ad hoc speed driven developments can help in ensuring more robust development regarding reliability, affordability, and sustainability of energy provision. This includes attention on aligning of simultaneous developments for renewable energy and intermediary and end goal articulation including the safeguarding of the principles of EU energy policy of affordability, sustainability, and reliable throughout the transition. This also implies operationalisation of the safeguarding of these three principles throughout the entire transition process *and* in the 2050 energy provision system.

10.7 Conclusion

This chapter provided insights in the versatility of efforts for creating a renewable future electricity system. A spectrum of decentralized renewable energy visions is simultaneously shaping the future electricity system. For depicting this versatility more extreme forms of distributed energy development in The Netherlands were analysed. The chapter specifically focused on communal energy and offshore wind.

A spectrum of renewable distributed developments are supported by the government of The Netherlands. The 2023 energy conservation targets appear leading. However, the separate elements in this plan are developing with limited attention for the consequences of these developments for the entire system. Also, for the planned developments, a spectrum of design choices can be made. In the case of offshore wind, near-term planning, a national focus, and the need for short-term results, led to rapid development and suboptimal design choices. For communal energy, the vision of the pioneering entrepreneurial actor is more important, which results in near-term development with unclear larger scale prospects.

The institutional developments need to accommodate the development of a divergent influx of electricity sources. The institutional setting needs to be developed that facilitates both centralized and decentralized energy generation and the interaction between these levels while accommodating the values of a (new) energy system (reliability, affordability, and sustainability).

Currently, there is little interrelation between these developments of these different scales (distributed and centralized), nor the integration of these developments in the national grid or the international market. The system boundaries of these developments are narrowly defined whereas interaction and attention for the process of systemic change is needed.

The actors guiding communal and offshore energy development are diverse. There are only a couple of actors that span across these realms such as governments, regulators, Transmission System Operators. The connection of the diverse developments towards a renewable energy system also needs to occur with coordination from these actors.

A development of an integrated vision that links current renewable energy initiatives with the ambition of an almost completely renewable energy provision in 2050, and the institutional and infrastructural options that accommodate design choices, can help this complex development process. Attention also needs to be paid to the stability of the developing renewable energy grid, especially in the transitional period in which there is (some) reliance on fossil energy.

When developing this synergy attention needs to be paid to the scales of these developments. Compared to decentralized communal developments, offshore wind energy is a far more centralized form of renewable energy development with different actors involved. Additionally, the central grid is increasingly used as a buffer zone to cope with fluctuations in demand and supply over the day and through the seasons this also needs to be incorporated.

The empowering and the inclusion of relevant actors on all of these levels in the envisioning process is crucial. This creates a nested, interrelated development. While it is valid for each actor to have its own motivation for supporting renewable energy development, it is important to have insight in how these developments add up to an institutional and infrastructure level.

Actors that support visions on either side of the spectrum should also be invited to identify linkages between the visions. The linking of these developments allows for contextualisation, innovation and experimentation as well as learning across different scales (Goldthau 2014). From there a well-informed reflexive vision can be developed that shapes developments and prevents sub-optimal lock-in.

The current omission of a long-term vision and the absence of infrastructure and institutional linkages between different elements of the renewable energy visions and developments, limit the benefits a vision may have in relation to reflectivity, learning, and integration. The synergy between the different developments is currently missing or at least underdeveloped. This is particularly important as ill integration may affect the principles of affordability, security of supply and sustainability that are core to our energy system.

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Chapter 11
Renewables and the Core of the Energy Union: How the Pentalateral Forum Facilitates the Energy Transition in Western Europe

Susann Handke

11.1 Introduction

In the European Union (EU), the geopolitics of renewables unfold against the backdrop of market integration and liberalisation as well as shared competences between the Union and its member states regarding energy policy. For decades, economic policies of the European Union have centred on market integration. Generally, the promotion of the single market re-shapes the relations among all actors in the targeted economic sectors. Beginning in the late 1990s, enhancing competition to improve cost-effectiveness provided the impetus for market integration in the electricity sector. In the early 2000s, the growing use of intermittent renewables to generate power in many EU member states emerged as an additional element that conditions integration measures in this sector. Hence, over the past two decades the objective of EU energy policy has shifted from primarily focusing on competitive markets for gas and electricity to a complex array of policy goals that eventually merged into the notion of the Energy Union. This new framework seeks to incorporate the various aspects of competitiveness, energy security, and decarbonisation of energy generation (European Commission 2015, 4).

Within the EU context, the deployment of renewables to generate electricity pertains to several policy fields, such as EU climate, environmental, energy, and competition policies. In addition, it reshapes cross-border relations of the member states. To cope with technical issues and keep the deployment of renewables cost-effective the interconnection of national grids is essential. Yet, establishing a Union-wide electricity grid requires both bilateral cooperation and coordination at the EU level. Consequently, promoting the generation and transmission of renewable electricity highlights the complexities of EU energy policy.

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Although all member states implement EU climate and environmental policies as well as measures to establish a single energy market, their schemes to decarbonise electricity generation diverge. During the first decade of the 21st century, the creation of a single market gained more importance in energy affairs as basis for guaranteeing EU-wide security of energy supply and environmental sustainability. Still, the composition of the energy mix remained a prerogative of national policymaking. Accordingly, measures to accomplish market integration consistently interact with national low-carbon policy choices.

The aim of becoming "the world leader in renewable energy," as the *2015 Energy Union Package* envisions (p. 15), and the simultaneous existence of nationally designed support schemes for renewables greatly influence the organisation of the EU electricity sector. Interconnectors between the grids of the member states are needed to control the cost of incorporating renewables to produce electricity. Moreover, the creation of larger balancing areas for intermittent renewable electricity is advantageous from a technical point of view.[1] Eventually, the power grids of the member states will have to form an interconnected network. To ensure the stability of the grid system, measures taken to develop national power sectors and renewable policies must dovetail with the ongoing electricity market integration.

However, the goal of linking national power grids faces numerous challenges. To decarbonise the single market for electricity, different levels of governance must bring in line diverging policies and regulation. Since there is a geographical aspect to grid interconnection, regional settings are key to a better coordination of national policies. Therefore, regional forums play a vital role in the process of restructuring the EU electricity sector. Initial Union-wide steps to institutionalise regional co-operation among EU member states date back to 2006 when the Electricity Regional Initiative[2] was launched.

In the previous year, the three Benelux countries Belgium, Netherlands, Luxembourg as well as France and Germany had created the Pentalateral Energy Forum (hereafter "Penta Forum").[3] Given the countries' geographic location and their economic gravity within the EU, experiences and outcomes of their regional

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[1] Transmission grids and new cross-regional or cross-border interconnections are cost-efficient alternatives to investments that are necessary to balance power systems with high shares of wind and solar electricity generation. See IEA (2016a, 173–195) for an overview of issues that are related to interconnected transmission networks.

[2] In 2006, the European Regulators' Group for Electricity and Gas (ERGEG), an advisory group to the European Commission comprised of the heads of national energy regulators, launched the Electricity Regional Initiative. It entailed the creation of seven regional electricity markets as an interim step to accelerate the process of market integration, i.e. the Baltic, Central-East, Central-South, Central-West, Northern, South-West, and France-UK-Ireland regional electricity markets.

[3] In 2011, Austria and Switzerland joined the Penta Forum as a full member and an observer, respectively. See, "Pentalateral Energy Forum," (in Dutch), http://www.benelux.int/nl/samenwerking/pentalateral-energy-forum.

cooperation carry considerable weight with those who design future EU energy policies.

This chapter analyses how the growing deployment of renewables in the power sector affects the cooperation among the members of the Penta Forum and how this institution helps them to address challenges that arise from the low-carbon power transition. Furthermore, it demonstrates how this regional institution evolved within the framework of an increasingly elaborate and Brussels-oriented mode of EU energy governance. To illustrate how the Penta Forum steers its members' electricity market integration, the chapter traces interactions between various levels of governance.

No doubt, the Penta Forum is an example of how interstate energy relations are transformed by the low-carbon energy transition. At the same time, it shows that renewables as part of this transition necessitate and can induce innovative forms of cooperation that enable states to proceed in a mutually beneficial and timely manner. Thus, by drawing attention to the Penta Forum this chapter shows how states can cooperatively advance their low-carbon power transitions under the specific circumstances of EU electricity market integration.

Since the large-scale deployment of renewable sources of energy in the EU electricity sector affects the political and economic relations between neighbouring states, conflicts resulting from different aims and economic interests with respect to renewables policies are likely to occur. Therefore, assessing these developments from a geopolitics perspective is worthwhile. This chapter thus explores how the transition towards renewable energy induces new patterns of cooperation among states.

In this regard, a study of the Penta Forum is particularly helpful for two reasons. First the forum's evolution highlights potential conflicts both in bilateral and EU contexts. Second, the development of the cooperation among the Penta states exemplifies how they succeeded in reconciling diverging national policies throughout the course of EU-wide electricity reform. This chapter answers the question of how the cooperation between the member states of the Penta Forum facilitates interactions between EU policies and national choices to pursue the energy transition. The conclusions are relevant to efforts to design new forms of transnational energy and climate cooperation and improve existing institutions.

Two important issues frame this chapter's narrative. They concern the need to engage in *cross-border cooperation* to accommodate the impact of deploying renewables in the power sector and the inconclusiveness of the current debate with respect to the *appropriate level of governance* that should administer the transformation process. The chapter argues that although the need to coordinate power transmission and trade inspired the creation of the Penta Forum as an institutional response to EU energy policies, cooperation between the Penta states is particularly important for dealing with more practical issues of national renewables policies. Thus far, EU legislation has only reluctantly recognised the institutionalisation of regional cooperation such as the Penta Forum. Moreover, the ongoing debate on the implementation of the Energy Union puts more emphasis on the EU level's decision-making power. However, the development of regional functional cooperation constitutes an important intermediate step in the ongoing process of EU market integration (Mohr 2011, 153). In this sense, settings such as the Penta Forum warrant more scrutiny.

The next section of this chapter outlines the specifics and benefits of this theoretical approach and explains how this chapter deploys constructivist theories to contextualise the evolution of the Penta Forum. Section three summarises the legal and institutional history of EU electricity market integration and efforts to promote the deployment of renewables. The fourth section briefly assesses the low-carbon power transitions in the Penta states, focusing on the policy choices of these states to increase the share of renewables in their electricity mix. Furthermore, the fourth section shows how these measures affect both the individual power sectors and cross-border cooperation that aims to establish the internal power market. The fifth section uses the constructivist theoretical framework, introduced in section two, to analyse the merits of the Penta Forum as a tool for balancing national renewables policies in the context of EU electricity market integration. The final section concludes and offers some policy recommendations.

11.2 A Constructivist Perspective on the EU Energy Transition

11.2.1 Ideas and Structures

The implementation of renewable policies in the power sector is dependent on previous and ongoing measures to liberalise the market for electricity. Since the late 1970s, neoclassical economic thinking has been transforming many economies throughout the world. Measures to liberalise economic sectors, which in the past were controlled by a monopoly or only a few actors, had tremendous impact on market structures,[4] in particular in network-dependent sectors such as telecommunication and power generation and transmission. Introducing renewables in the electricity sector also requires far-reaching structural adjustments, such as rules that guide the shift towards decentralised power generation, the deployment of new technologies, and the balancing of intermittent production patterns.

Since this process is evolving within the framework of liberalised electricity markets, the ideational concept of decarbonising electricity generation has to square with the ongoing market liberalisation. Thus far, liberalisation has led to diverging outcomes, in particular in the EU context with the twin goals of liberalisation and Union-wide market integration. Moreover, the introduction of renewables proceeds in the context of market structures that evolved in a fossil-fuel-based sector.

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[4] The term “structures” is used in the sense of institutions and norms, including laws and regulations.

Each EU member state faces different challenges. Factors that relate to geography and the characteristics of the energy mix are relevant; and all regulatory measures to promote renewables have to fit in with the degree of liberalisation that has been achieved in its domestic electricity market.

This chapter discusses this multifaceted reorganisation of the European electricity sector within a constructivist theoretical framework. It specifically relies on a constructivist perspective on the international political economy. This theoretical approach, as put forward by Blyth (2002), centres on the way in which ideas bring about economic transformations and is particularly useful for analysing large-scale politico-economic shifts.

In his study on economic policies in the late 20th century, Blyth shows how economic ideas—or shared understandings—gained ground among relevant actors under diverging politico-economic circumstances. This dynamic helps explain the transformation that led to the implementation of liberalisation policies in economies with *laissez fair*-leaning elites as well as in states whose political elites adhere to centre-left convictions.[5] Thus, instead of merely focusing on power and material interests—as rationalist theorising would suggest—capturing changing perceptions and identities is key to a constructivist analysis of the dynamics that were at the basis of liberalisation policies.

This chapter conceptualises the need to decarbonise power production in liberalised electricity sectors as an idea or shared understanding among the relevant actors. This conceptualisation is mainly based on the discourse on climate change mitigation, entailing all efforts to fend off dangerous levels of carbon dioxide (CO_2) concentration[6] in the atmosphere. The issue of reducing CO_2 emissions has become one of the most pressing problems of humankind that require a global response.[7] Switching the production of electricity from fossil fuels to renewable energy sources is a crucial measure to decarbonise economic activity.

The notion that the low-carbon power transition has to proceed within the regulatory framework of market mechanisms became the basis of policymaking to develop and (re-)design the structures of the electricity market in all EU member states. This conceptualisation does not omit the fact that particular material interests and instances of "obstruction" by powerful incumbents in several member states

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[5] Blyth contrasts the pursuit of liberalisation policies in the United States of America and Sweden. Eventually, the economic idea of having liberalised markets as the basis of a modern capitalist economy became accepted in both states and shaped policies to regulate the economy. See, in particular, Blyth (2002), 152–247.

[6] Carbon dioxide (CO_2) is one of the greenhouse gases that are trapped in the atmosphere, causing human-induced climate change. CO_2 is by far the most important driver of anthropogenic climate change. CO_2 is emitted in the course of combusting fossil fuels (coal, natural gas, oil). With a share of 90%, it dominates energy-related greenhouse gas emissions (IEA 2016b, 9).

[7] The global discourse on mitigating climate change culminated in the adoption of the United Nations Framework Convention on Climate Change in the context of the 1992 Earth Summit in Rio de Janeiro, Brazil. See for an overview of the history of climate change negotiations and governance, Gupta, Joyeeta, *The History of Global Climate Governance*, Cambridge: Cambridge University Press, 2014.

cause delays and failures of specific policy measures. Since this is the normal course of action, such incidents can hardly be used to disprove the premise that ideas or shared understandings about decarbonising electricity production are at the core of the dynamics that are reconfiguring the entire electricity sector.

Since constructivist theorising on international political-economic issues considers economic ideas as the main drivers of economic change, instead of power and material interests of the actors, this branch of research on the political economy acknowledges the mutually reinforcing relationship between the identity of actors, shared understandings (ideas), and structures (norms and institutions). Accordingly, in this chapter the nature of the energy system of a certain state is considered as an identity-shaping factor. This identity determines a state's perceptions of its energy relations and, specifically, its government's involvement in transnational cooperation to implement renewables policies, such as the participation in the Penta Forum.

With the increasing emphasis on low-carbon energy production, the main actors in every national energy sector are experiencing a reconstitution of various economic, political, and regulatory structures. The centre of power production might move from one part of the country to another or spread towards rural areas, affecting the planning of transmission networks and, subsequently, shifting economic activity, financing, and employment from one area to another (both geographically and sector-wise) or from urban centres to rural communities. These changes create opportunities. But more often than not they have unforeseen or negative consequences, forcing policymakers to constantly reconsider various options for pursuing the energy transition.

Nevertheless, the national debate on the parameters of the energy transition gradually re-imagines the energy sector. Based on this re-imagination, the facets of a decarbonised energy sector and energy mix evolve. This is the idea of an energy future that policymakers rely on when they design low-carbon policies, such as renewables support schemes and the planning of the grid. Re-imaging the nature of a state's power sector changes that state's identity in its energy relations. Following international negotiations, new norms and institutions (structures) emerge. These structures continue to interact with identities and ideas. By studying these dynamics, this chapter offers a novel perspective on the challenges and opportunities for cooperation in the context of the low-carbon power transition.

From a substantive perspective, existing research on the electricity market integration and promotion of renewables in the EU either focuses on the interplay of EU and national laws and regulation (Reiche and Kohler 2005; Rusche 2015) or explores options for regional cooperation (De Jong and Egenhofer 2014; De Jong and Groot 2013). Thus far, the scholarly discourse only insufficiently addresses the response to geopolitical challenges that result from the ongoing interaction between the EU level of governance and national policymaking in the context of EU renewables policies and frictions among member states. This chapter studies these developments. It discusses both regulatory aspects of renewables measures and EU market integration from national and EU angles as well as regional aspects. This multilevel analysis helps to draw some conclusions on tools that can address the geopolitics of renewables in the EU, an issue that is otherwise blurred by bilateral interactions or the polarity of "Brussels vs. the member states." This approach provides new insights into broader trends of EU integration that shape the regional integration of EU member states' electricity markets.

Accordingly, this chapter avoids portraying the realm of EU energy policy as an arena of conflicts centring on power and material interests or regulatory divergence. Instead, it deploys constructivist theorising to detect how interactive processes turn ideational concepts into new structures that can guide cooperation. By assessing regional efforts to cooperate, this chapter elucidates how these structures evolve and function. The findings of this chapter explain a vital aspect of EU energy governance and can be utilised to prevent serious frictions in the course of the low-carbon energy transition within the EU and among neighbouring states beyond the Union that seek to both integrate grid infrastructure and harmonise electricity regulation.

11.2.2 Differentiated Integration

The harmonisation of EU policies differs both in depth and geographical extension. This chapter follows Manuel Mohr's approach (2011) and considers the establishment and utilisation of the Penta Forum as a form of differentiated integration to demonstrate how EU policies guide decision-making in its member states and facilitate compromises on salient economic issues.

Policies that seek to accomplish the integration of the EU member states' economies have been evolving since the late 1950s. Leuffen et al. (2013) highlight the fact that many policies were implemented gradually and did not involve all states from the outset. Some states opted out of certain fields of cooperation, while others could only join these policies after several rounds of EU enlargement. The introduction of the euro as common currency and the evolution of the Schengen area are cases in point. Hence, the EU can be imagined as a "system of differentiated integration" (Leuffen et al. 2013, 1, 10).

The description of the EU as a system of differentiated integration—or as characterised by a "variable geometry" (Usher 1997; De Witte 2015)—acknowledges that European integration has thus far resulted in "an organisational and member states core," while the level of centralisation and territorial extension of policy integration vary by function (Leuffen et al. 2013, 10). By using the concept of differentiated integration, this chapter can put regional cooperation among Penta states into perspective and relate this institution to the extent of centralisation efforts at the EU level without over-emphasising frictions between Brussels and national preferences.

Studying the evolution and role of regional cooperation efforts to decarbonise power generation illuminates how reconciliation can take place between Union-level and national objectives as well as in the bilateral and regional contexts. From the outset, every new legislative instrument and policy initiative on electricity market integration sought to increase the room for decision-making at the Union level. Consequently, the geopolitics of cross-border renewable electricity in the EU, with its regional allegiances, strongly interacts with the evolving framework of the Energy Union. By conceptualising the cooperation within the Penta Forum as differentiated integration, this chapter features these interactive processes and enhances the analytical scope of the discussion about EU renewables policy. This approach is worthwhile, as it allows for considering national policy choices and the cooperation among the member states of the Penta Forum as embedded in EU energy policies. To delve into the topic, the next section starts off with an overview of EU policies to create a common market for electricity and promote the low-carbon power transition.

11.3 EU Electricity Market Integration and the Promotion of Renewables

11.3.1 Centralizing EU Energy Governance

Two features characterise the development of the EU electricity sector from the 1990s onwards. They concern the challenges that EU energy policies have to deal with and general matters of EU governance. First, the parallel evolution of liberalisation and low-carbon policies led to inconsistent legal instruments that were (at least initially) ineffective with respect to both the creation of a competitive internal market and the promotion of low-carbon electricity. The integration and liberalisation of the electricity market only progressed slowly, mainly because national incumbents sought to postpone the process. Other reasons for the delay were the lack of innovation at the time of market integration, which distinguishes the case of power sector liberalisation from experiences in the telecommunication sector, difficulties to trade electricity, and the various relationships that existed between national power sectors, other branches of the economy, and political elites that could not easily be consolidated at the EU level (Glachant 2013, 34).

Second, the competence for market integration is situated at the Union-level, while in accordance with the principle of subsidiarity the composition of the electricity mix is decided at the national level. A top-down approach to Union-wide electricity policy seems infeasible, mainly because regulators have to deal with complex technical issues. Such issues often occur at local and regional levels in the course of establishing and governing power transmission infrastructure. However, national governments struggle to accomplish the low-carbon transition cost-effectively. Therefore, in the mid-2000s the meaningful integration of the two pillars of EU energy policy—market integration and low-carbon transition—emerged as a big challenge (Helm 2014, 31–4). Hence, with the increasing deployment of renewables the policy fields of market integration and energy transition have become ever more intertwined, while many issues remain unresolved and could potentially lead to frictions between EU member states and the European Commission or among member states.

Diverging national support schemes for renewables and the need to construct necessary transmission infrastructure in a timely manner are key issues that could cause conflicts. In fact, from the outset the European Commission tried to harmonise national support schemes that promote renewable electricity, but faced considerable resistance based on the principle of subsidiarity (Rusche 2015, 26–33). Another issue was the introduction of quotas of renewables in the electricity mix for all member states. The first renewables directive (Directive 2001/77/EC) did not prescribe quotas but opted for national indicative targets (Article 3).

In 2007, the Council of the European Union adopted the 20-20-20 Strategy.[8] This resulted in an effort to review the first Renewables Directive and consider both the harmonisation of support schemes or, alternatively, cross-border trade of renewable electricity. Eventually, some form of flexibility with respect to national support schemes was made possible. Article 6 of the second renewables Directive 2009/28/EC allows member states to trade excess production of renewable electricity. Furthermore, member states can implement joint projects (Articles 7–10) or establish joint support schemes (Article 11). In addition, national targets for renewable electricity became binding (Article 3). Yet, the member states are free to determine how to achieve their targets (Rusche 2015, 38). In the absence of a leading and coordinating role for the European Commission, the member states are largely left to their own devices to decide how to achieve a balance between the deployment of renewables and further market integration. Hence, this situation created a certain responsibility on the part of the member states to come up with suitable governance solutions to promote cooperation on these issues.

From a practical perspective, the nexus of market integration and renewables promotion is the cross-border interconnection of power grids and the impartial access to transmission and distribution networks. Moreover, the design of support schemes for renewables must be suited to the overall objective of creating a competitive internal energy market. Therefore, the establishment of the internal power market and measures to promote the generation of electricity from renewable sources of energy have to evolve in parallel.

In the EU, the coordination of both policy fields had been insufficient from the beginning. The inconsistency of climate and energy policies at least partly resulted from the division of competences between the Union-level and the national governments (Nettesheim 2010) and the organisation of the European Commission.[9] In fact, the problem of inconsistency concerned the whole range of EU policies that

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[8] The March 2007 conclusions of the European Council envisioned an "integrated climate and energy policy" for 2020, which included reducing 20% of the Union's greenhouse gas emissions by 2020 compared to 1990, saving 20% of the Union's energy consumption compared to projections for 2020, and having a 20% share of renewables in overall EU energy consumption. See Council of the European Union, "Brussels European Council—8/9 March 2007: Presidency Conclusions," 2 May 2007, 7224/1/07 REV 1, pp. 12, 20, 21.

[9] Until 2010 the Directorate-General TREN (transport and energy) was responsible for the policymaking on energy market integration. The Directorate-General CLIMA deals with EU climate policy. It was established only in 2010.

are key to the decarbonisation of electricity generation, i.e. market integration and the interaction between policies to promote renewables and to establish the EU emission trading system (Lehman and Gawel 2013; Koch et al. 2014).

The task of legislating both the integration and decarbonisation of national electricity sectors is complicated by the locale of competences. The Union-wide process of power market liberalisation and integration began in the late 1990s. In the early 2000s, the first low-carbon measures were implemented. The high frequency of amendments and repeals illustrates the enormous difficulties that the European Commission and national legislators faced when they simultaneously implemented market liberalisation and low-carbon policies, as both policies aim to achieve very complex and testing transformations that are not necessarily compatible.

The first legislative instrument to liberalise and integrate the power sector was Directive 1996/92/EC, while Directive 2001/77/EC initiated the promotion of renewable energy sources in this sector. In 2003, the second electricity market Directive 2003/54/EC was passed. The directives to deploy renewables and promote market liberalisation were both amended in 2009. The market liberalisation legislation was presented as the "Third Energy Package," including relevant directives and regulations for both the gas and electricity sectors. Following the above-mentioned 20-20-20 Strategy, this package was accompanied by measures to address climate change, in particular to increase the share of renewables in EU energy consumption to 20% by 2020.

Legislation that has been passed from 2009 onwards contains significant measures to advance both the decarbonisation and integration of the Union's energy market. This indicates an increasingly comprehensive, long-term approach to regulating the transformation of the entire energy sector. The second renewables Directive 2009/28/EC not only concerns the electricity sector but covers the use of renewable sources of energy in general. The third electricity market Directive 2009/72/EC and Regulation 714/2009 that accompanied this directive seek to further restructure the electricity sector and create a regulatory framework for cross-border electricity transportation and sales. In addition, Regulation 713/2009 establishes the Agency for the Cooperation of Energy Regulators (ACER). This agency monitors the market integration as well as the cooperation between national transmission system operators.

The successive legislative instruments that were promulgated to integrate the market for electricity and promote renewable electricity moderately increased the vertical integration—i.e. the EU role in policymaking for the electricity sector (Wettestad et al. 2012, 73–74)—and enables the European Commission to improve the coordination of both policy fields. Moreover, the announcement of the Energy Union in 2015 constituted a qualitatively new approach, entailing a reform of EU energy governance that can further foster harmonisation and coordination (Szulecki et al. 2016, 548–549). Still, new governance structures will have to acknowledge the underlying tensions between a European approach and national energy policies (Szulecki et al. 2016, 553). Omissions in previous legislation to promote market integration and renewables offer some conclusions with respect to necessary regulatory efforts to deal with these tensions.

A close reading of past legislative instruments reveals the inconsistency of the policy goals. The first electricity market Directive 1996/92/EC aimed to establish a competitive electricity market in order to "increase efficiency in the production, transmission and distribution" of electricity (recitals 2, 4). In fact, this directive sought to promote market liberalisation within the individual member states (recital 22) rather than immediately accomplish a cross-border interconnection of all power systems. It merely called for "a directly comparable level of opening-up of markets" and "a directly comparable degree of access to electricity markets" as a precondition for market integration (recital 12). Still, Directive 1996/92/EC in recital 21 referred to Decision No 1254/96/EC that identified several trans-European energy networks,[10] including the interconnection of transmission lines between EU member states and stated in recital 22 that it is "necessary to establish common rules for the production of electricity and the operation of electricity transmission and distribution systems." Hence, the objective of liberalising *national* electricity markets was tentatively accompanied by efforts to interconnect the power grids of the member states.

The wording of the second electricity market Directive 2003/54/EC acknowledges that this approach had been too reluctant. Directive 2003/54/EC stresses the need for "a fully open market, which enables all consumers freely to choose their suppliers and all suppliers freely to deliver to their customers" (recital 4), while calling for more efforts "to ensure efficient and non-discriminatory network access" (recital 8). Thus, Directive 2003/54/EC further advances the liberalisation of the electricity markets. To facilitate the Union-wide interconnection of power grids, Directive 2003/54/EC calls in rather vague terms for the creation of independent regulatory authorities that should monitor the operation of the market mechanisms and—"in conjunction with the regulatory authority or authorities of those Member States with which interconnection exists"—manage and allocate interconnection capacity (Article 23 (1) (a)). Articles 11 (3) and 14 (4) *allow* member states to legislate that transmission system operators and distribution system operators give priority to power generated from renewables.

As a result of this vagueness in the legislation and reluctant efforts in the member states to implement liberalisation measures, the EU electricity sector is very divergent and fragmented. The implementation of the renewables policies also varied considerably among the member states, with different support schemes restricted to national power markets. To meet their national targets for the share of renewables in their electricity mixes, all member states created national regulatory designs. On its part, the European Commission failed to establish an internal market for renewable electricity between 1999 and 2008 (Rusche 2015, 4, 174).

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[10] An "indicative list of projects of common interest" is included in the annex to Decision 1254/96/EC.

Given these difficulties, a more comprehensive approach to both market integration and the low-carbon power transition was inevitable. Since the European Commission initially sought to achieve the liberalisation and interconnection of the member states' power sectors, the first two electricity directives dealt with the past —i.e. nationally confined energy systems and monopolistic or oligopolistic sector organisation (Glachant 2013, 36). Only in 2007, a new EU energy policy, including the 20-20-20 Strategy, was presented that addressed energy security, competition issues, and climate concerns. Subsequently, the Directorates-General Competition and Energy of the European Commission co-drafted the new energy legislation and cooperated to put an end to outdated market structures (Wettestad et al. 2012, 80–81).

In 2009, the previous legislation to integrate the European electricity market was repealed by the instruments of the Third Energy Package; and a new renewables directive was passed. From 2009 onwards, new legislation tried to both correct previous omissions and ensure effective implementation. In 2012, the European Commission issued a communication on the role of renewables beyond 2020. By that time, renewable energy will have to be integrated in the internal market with reduced or no support. The reform of support schemes should move "as rapidly as possible to schemes that expose producers to market price risk to encourage technology competitiveness" (European Commission 2012, 4). Thus, renewables are becoming an inseparable part of the internal market for electricity.

For years, market participants and governments have relied on regional cooperation structures to facilitate this ongoing process, by providing a sufficient level of cross-border interconnection. During the mid-2000s, larger interconnected power markets became a necessity because of the increasing deployment of renewables. The geographical area around Germany is a case in point. Following the implementation of a massive government support scheme for renewable electricity, Germany's neighbours had to cope with increased electricity exports originating from wind and solar power generation. To deal with this challenge, neighbouring states must reinforce their cooperation within the multi-level legal framework that emerged in response to EU policies to integrate electricity markets.

11.3.2 A Constructivist Perspective: EU Energy Policy—A Shared Understanding?

In the early 2000s, EU energy policy was still fragmented. It was mainly characterised by the aim of the European Commission to liberalise the gas and electricity sectors, focused on enabling more competition. Only in 2001, the first legislation was issued to address sustainability concerns but clashed with national policies that the member states either had already in place or were designing at that time. The clear preference of the Commission for tradable certificates invalidated the policy experiments that were conducted in the member states. Eventually, feed-in tariffs became the most widely used support scheme in the member states. However, as they were limited to national markets, they were not suitable for a single EU electricity market.

Two important external factors created a momentum for enhancing efforts to integrate the EU energy market. First, with the wave of enlargement in 2004 and 2007 eastern European states joined the EU that considered their import dependence on Russia a significant weakness. A functioning internal market with free flows of energy supplies could alleviate these states' anxiousness about their security of energy supply. Second, in 2005 the Kyoto Protocol (1998) entered into force. For developed economies, the protocol states binding targets for reducing greenhouse gas emissions—most importantly CO_2 emissions. The EU had accepted a combined target for reducing its emissions by 8% compared to the base year level of 1990 (Annex B of the Kyoto Protocol). Resulting from its wish to present itself as a vanguard of global climate change mitigation and the need to decarbonise energy generation, the EU enhanced its efforts to pursue a more comprehensive energy and climate policy in the following years.

During the 2000s and 2010s, the Commission issued various policy strategies that sought to better streamline the approaches to both policy fields. As the market integration among member states and the conversation between Brussels and national capitals is proceeding, energy and climate policies are increasingly complimentary. Accordingly, in the process of these interactions the notion of shared competences between the EU level and member states is being clarified. From the early 2000s onwards, the European Commission has expanded its internal competences, and to a lesser degree with respect to external aspects of energy policy (Maltby 2013, 441). Subsequently, the EU level has been able to develop an all-encompassing energy policy, leading to policy proposals that promote market integration and answer to national needs and interests concerning security of supply and sustainability matters. Consequently, a shared understanding of an Energy Union is gradually emerging among EU member states that relies on an ever more expanding body of EU energy law and policies that is increasingly succeeding in avoiding frictions and guiding the dialogue and cooperation between stakeholders.

11.4 Pentalateral Forum and Its Member States

11.4.1 Pentalateral Forum and the EU Electricity Market

The low-carbon transition and in particular the large-scale deployment of renewable sources of energy in the Penta states will be determined by the success of the regional power market integration. The establishment of the Penta Forum can be seen as an attempt to overcome tensions that arise from Union-level efforts to integrate the electricity market and the fact that the member states retain the competence to determine their national electricity mix.[11]

Despite decade-long efforts to establish the internal market for electricity, three main obstacles persistently led to delays—market concentration, the principle of subsidiary, and lacking transmission infrastructure (Mohr 2011, 149). Obviously, these obstacles relate to very divergent aspects of power sector governance. First, the problem of market concentration derived from the fact that national power sectors were originally organised around one or only few main power providers. The slow implementation of the first and second liberalisation directives prevented the entry of new actors or the expansion of power generating companies from one member state to others. Second, oligopolistic market structures impeded the development of cross-border power exchanges, as network companies were unwilling to speed up the construction of transmission lines and interconnectors. Third, in the case of power market regulation the principle of subsidiarity hinders the smooth progress of policy development and planning. The division of competences between the European Commission and the member states caused delays and too much diversity in the implementation of market regulation directives. Hence, the extensive room of manoeuvre for national governments with respect to the implementation of the liberalisation approach resulted in various market designs, property structures, regulatory systems for network operators, and competences of regulators (Mohr 2011, 149–151).

To address these matters of market governance, two options were available. The European Commission could further seek to strengthen its competences and increase its efforts to centralise market regulation or it could leave more responsibility to decentralised schemes of cooperation. Since the member states did not favour more influence of the Union-level on national energy policy, the European Commission opted for new modes of governance (Eberlein 2008, 73–92). Forums of sectoral and regional cooperation emerged as useful alternatives. From the outset, these forms of governance were considered as necessary intermediate steps to further, Union-wide harmonisation of power market governance (Mohr 2011, 153).

The bottom-up process of establishing new forms of sectoral governance mainly relied on two institutions that were set up to facilitate the informal dialog among market actors—i.e. the Florence Forum and the European Regulators' Group for Electricity and Gas (ERGEG). In 2003, the Council of European Energy Regulators proposed to create regional structures for cooperation to promote market integration at this intermediate level. Subsequently, this proposal was further elaborated; and in 2006 ERGEG presented the Regional Initiatives as a new governance model to coordinate power market integration.

Among the seven overlapping regional markets, power trade is most significant in the central and western European area. Following the decision to create a coordination mechanism to facilitate regional market integration, the governments of France, Belgium, Luxembourg, the Netherlands, and Germany signed the

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[11] Pentalateral Energy Forum, http://www.benelux.int/nl/samenwerking/pentalateral-energy-forum.

Memorandum of Understanding of the Pentalateral Energy Forum on Market Coupling and Security of Supply in Central Western Europe[12] on 6 June 2007 and institutionalised their informal regional cooperation.

The Penta Forum was established by representatives of the national regulatory authorities, transmission system operators, power exchanges, and the market platform parties of the five states. The Penta Forum constitutes an intergovernmental initiative and is hosted and facilitated by the Benelux Secretariat. Its declarations are not legally binding. The emphasis is on cooperation and dialog.

The Memorandum of Understanding (MoU) considered the functioning of the market and security of supply, in particular with respect to the complexities of cross-border flows and intermittent power production from wind turbines, as the main basis for promoting more cooperation among the Penta states (para 1–2). By doing so, the MoU referred to the then relevant EU electricity legislation,[13] previous informal consultations between representatives of the involved stakeholders and governments, as well as the Regional Action Plan (para 3–5).

The MoU states as the objective of the cooperation among the members of the Penta Forum "the analysis, design and implementation of a flow-based market coupling," which should be achieved by January 2009. Accomplishing the objective "should support wider European integration" (para 7). In this process, the role of the Penta Forum should be "to resolve upcoming issues and any issue hindering the timely progress of the Memorandum of Understanding projects" (para 8). To identify problems that need further dialog, the ministries of the Penta states regularly review and engage in the process, especially concerning legal and regulatory obstacles (para 9). The regulators monitor the ongoing technical and regulatory developments and the implementation of the Regional Action Plan. The coordination proceeds based on "a joint and efficient decision-making procedure" and by stressing mutual support (para 10).

The forum is subdivided in Support Groups on market integration (SG1) and on security of supply (SG2). The meetings of the support groups are chaired by the so-called Penta Coordinators who are representatives from the ministries of energy.[14] In addition, the ministers of energy meet regularly to discuss regional energy issues. The ministerial conference is the governing body of the Penta Forum. The ministers of energy jointly decide on all goals. They take decisions by consensus. The main approach of the Penta Forum is to issue action plans on technical issues related to market coupling and cross-border transmission. The coordinators' committee, consisting of representatives from all Penta states, meets at least twice a

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[12] See website of the Pentalateral Energy Forum, http://www.benelux.int/files/3214/2554/2929/Memorandum_of_understanding_Pentalateral_2007_-_EN.pdf.

[13] Directives 2003/54/EC, Regulation 1228/2003 as well as Directive 2005/89/EC.

[14] See website of the Pentalateral Energy Forum, http://www.benelux.int/nl/kernthemas/holder/energie/pentalateral-energy-forum/.

year. It discusses current issues and makes sure that consensus over the actions in the working programme remains guaranteed.[15]

In 2008, the Penta states founded the Capacity Allocation Service Company CWE S.A., which is headquartered in Luxembourg. It provides cross-border allocation services and long-term auction services of power transmission capacity to the interconnectors in the participating states. After successfully coupling the national power markets in 2010, the cooperation intensified. In 2011, following Germany's announcement of enhancing its energy transition, new momentum was created for extending cooperation in the electricity sector (De Jong and Groot 2013, 27). In the same year, Austria joined the Penta Forum as a member state; and Switzerland became an observer.

The *2013 Political Declaration* describes the Penta Forum as a "relevant framework" in the context of the energy transition.[16] This evidences the fact that the Penta states were increasingly aware of the need to adjust the development of the regional electricity market to this salient transformation. In 2015, the ministers signed another political declaration, including a new action plan. One of the tasks is to explore options that make power markets more flexible. The implementation of flexibility mechanisms is considered as "an essential condition for delivering security of supply in a cost-effective manner," given "an increased share of renewables in the systems."[17] This task is further elaborated in several action points and illustrates the engagement of the Penta Forum with the development of the power sector beyond market integration. In other words, renewables policies have already become a major issue in the coordination of national market policies among Penta states. Although the cooperation in the Penta Forum was originally inspired by the integration of electricity markets, the need to deal with renewable electricity emerged as a significant driver of cooperation after 2011.

11.4.2 Responding to Germany's *Energiewende*[18]

By the early 2000s, all EU member states had begun to consider policies to increase the share of renewables in their electricity mixes. The first renewables Directive 2001/77/EC states in Article 3 that the EU seeks to achieve a share of 12% of renewables in its electricity mix. To implement this goal, EU member states were required to develop national indicative targets (recital 7). In addition, national governments increasingly viewed the promotion of renewables policies as

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[15] See "Annex 2—Governance" of the Second Political Declaration of the Pentalateral Energy Forum, 8 June 2015, http://www.benelux.int/files/1214/3472/2463/Penta_signed.pdf.

[16] 2013 Political Declaration of the Pentalateral Energy Forum, http://www.benelux.int/files/5014/2554/2983/PoliticalDeclarationOfThePentalateralEnergyForum_2013-EN.pdf, p. 2.

[17] 2013 Political Declaration of the Pentalateral Energy Forum, p. 6.

[18] *Energiewende* is the German term for energy transition.

beneficial for several reasons, such as the reduction of air pollution, support for new industries to create jobs, and increasing energy security. These factors, together with technological progress and rising prices for oil and gas, created an increasingly favourable policy environment to contemplate more profound renewable measures. However, Danyel Reiche and Mischa Bechberger conclude that due to diverging national circumstances there was no measure that was suitable for all member states (2004, 846–849).

From the outset, the coordination of the European Commission's preferences and national policy choices to implement the first renewables directive proved difficult. The Commission sought to find support for tradable green certificates, while most member states eventually opted for feed-in tariffs to promote renewable electricity (Rusche 2015, 68–76). The trend towards feed-in tariffs had been visible since the early 2000s. Yet, the rigour of the support schemes and the legal certainty that these schemes could provide to potential investors varied considerably, also among the Penta states.

There are two important turning points that changed the conversation. First, when the Kyoto Protocol entered into force the international legal environment changed. The need to implement low-carbon measures to mitigate climate change became a necessity. Second, in the context of EU renewable policies the year 2011 was a watershed, mainly because Germany re-iterated previously shelved plans to phase out its nuclear power generation after the catastrophe at a nuclear power plant in Fukushima, Japan. This decision entailed a tremendous increase of renewable electricity generation to replace the amount of nuclear-based electricity. Chancellor Angela Merkel presented her decision as an excellent opportunity for Germany for becoming a world leader in renewables.[19] There was also sufficient support among the German public, the business community, as well as legislators.

Germany's turnabout accelerated and extended the cooperation among the Penta states. During the mid-2000s, coordinating cross-border integration of the grids and technical adjustments related to interconnection issues were central to the establishment of the Penta Forum. After 2011, however, Germany's switch to quickly increasing large-scale renewables deployment necessitated a broad coordination of renewable policies and grid planning.

During the mid-2000s, first instances of cooperation were hardly inspired by the wish of the Penta states to coordinate renewable policies. At that time, the discourse on the implementation of renewables policies was dominated by national considerations. Although it is beyond the scope of this chapter to summarise the evolution of the renewables policies of all Penta states, a snapshot of the situation around 2005 helps to shed a light on the paradigm shift that clearly gained momentum after Germany's accelerated *Energiewende*. Moreover, an overview of how policies to promote renewable electricity emerged points to potential conflicts that could have

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[19] "Merkel: Atomausstieg eine riesige Chance für Deutschland" [Merkel: nuclear power phase out is a golden opportunity for Germany], *Frankfurter Allgemeine*, 30 May 2011, http://www.faz.net/aktuell/politik/energiepolitik/atomausstieg-bis-2022-merkel-eine-riesige-chance-1643205.html.

resulted from a continued uncoordinated implementation of purely nationally oriented measures. Indeed, a review of the development of renewable electricity in the Penta states by the mid-2000s demonstrates which national parameters had shaped the debate and which obstacles a national approach would face.

In Germany, the first legislative act to introduce renewable electricity was enacted in 1991.[20] The first version of the current legislation—the Renewable Energy Sources Act—was passed in 2000. Two aspects were decisive for the progress of Germany's renewables policies. First, the Renewable Energy Sources Act and its subsequent amendments provide long-term security for investors for up to 30 years. Second, public acceptance of implementing renewables policies was high. By 2004 the renewables sector had already created 130,000 jobs. Yet, the extension of grid infrastructure lagged behind and became an important obstacle to the implementation of renewables policies (Grotz 2005b, 154–156).

In other Penta states, the implementation of renewables policies in the electricity sector encountered several problems during the early 2000s. In the Netherlands, political instability caused investors to doubt the long-term perspectives of renewable investments (Reiche 2005, 241). In France, vague planning procedures impeded the development of wind energy. The focus on the country's nuclear programme delayed the development of renewable energy sources other than hydropower (Grotz 2005a, 134–135). In Luxembourg, the government lacked political commitment to pursue a forward-looking renewables policy. The main political parties envisioned only a marginal role for renewables in the country's energy supply (Kox 2005, 226–227). The Belgian renewables policies evolved in the context of the devolution of power to the three federal entities. As a result, three divergent renewables policies developed. Progress was largely hampered by political and institutional constraints, but also by limited natural resources in combination with a high population density (De Lovinfosse and Varone 2005, 78–81). In Austria, the development of renewables to generate electricity faced considerable resistance from important branches of the business sector. The manufacturing industry sought to minimise costs, while the tourism sector specifically opposed the construction of wind farms (Lauber 2005, 66–67). Yet, after 2005 all Penta states intensified policymaking to design renewable measures. The share of renewable energy sources in electricity consumption increased in all Penta member states.[21] Next to national preferences, the current policy framework exhibits two

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[20] See for an overview of all legislative measures, Federal Ministry for Economic Affairs and Energy, "Overview of Legislation Governing Germany's Energy Supply System: Key Strategies, Act, Directives, and Regulations/Ordinances," http://www.bmwi.de/Redaktion/EN/Publikationen/gesetzeskarte.pdf?__blob=publicationFile&v=6.

[21] See for an up-to-date overview of national renewable legislation and regulation, IEA/IRENA database of renewable policies and measures at https://www.iea.org/policiesandmeasures/renewableenergy/; see for an overview of the percentages of renewables from 2004 onwards, Eurostat, "Electricity Generated from renewable sources," http://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=tsdcc330

main pillars—i.e. EU climate and energy policies and the coordination of grid development and interconnection in the Penta Forum.

11.4.3 A Constructivist Perspective: Ideas, Interaction, Shared Understandings

The previous sub-section showed which factors initially shaped national policies to promote renewable energy sources in the power sector. It is important to contrast predominantly national approaches with the cooperation between the Penta states that developed after 2011. A constructivist reading of the paradigm shift explains how cooperation instead of conflict became the main trend in this regional setting.

Initially, most Penta states implemented renewables policies with a clear focus on environmental considerations. Yet, these measures were not understood as the start of an energy transition but as a marginal part of the energy system. Shifts in political preferences then terminated these policies without replacement. Other objectives were the promotion of new industries and the improvement of the national energy security situation. Indeed, most Penta states rely on imports of fuels to satisfy their energy demand.

Only gradually the parameters of decarbonising the energy system evolved and policymakers understood the scope of this transition. Key events were the entry into force of the Kyoto Protocol that entailed binding obligations to reduce carbon emissions and the 2011 announcement by the German government to expand its renewables policies, which in turn had far-reaching consequences for the further integration of the regional electricity market.

The realisation among EU member states that the energy transition would have a considerable impact on their respective national energy systems led to an adjustment of how the energy sector was imagined. In other words, the identity of the states with respect to their energy situation—especially the future energy mix—was reconsidered and resulted in other policy preferences than only a few years earlier. The energy transition—like the liberalisation of the power market—became a shared understanding on which cooperative structures can be based.

The Penta Forum provided a depoliticised environment where ministers and representatives of regulatory bodies can meet to discuss rather technical aspects of market integration and policy planning. This depoliticised set-up is key to the success of the Penta Forum. It liberates the debates from domestic political conflicts and does not replicate the paradigm of “Brussels vs. national governments.” In this setting, problems and preferences can be brought up and analysed, while gradually an image of the regional market evolves. Consensus-based decision-making presupposes a shared understanding. Hence, renewables policies in the context of market integration constitute an idea or shared understanding in the sense of constructivist thinking. Such ideas then lead to structures—rules and institutions—that guide common, cooperative action.

11.5 Reconciling National Energy Transitions

11.5.1 What Is at Stake?

The assessment of the interaction between EU and national electricity governance demonstrated that causes of conflict mainly relate to two issues. Member states might infringe on EU legislation by hampering market integration or diverging interests of the stakeholders in the Penta states could lead to a politically unfavourable situation that then impedes further regional electricity cooperation. The previous section explained how initial renewables policies were designed. Most policies were developed based on sustainability considerations, while also seeking to foster industrial policies or energy security. Moreover, national renewables support schemes—mainly feed-in tariffs—generally were not suited for cross-border trade in renewable electricity. Hence, without coordination neighbouring states easily perceive each other as competitors when pursuing these policies under rather comparable geographic and institutional circumstances.

Yet, the fact that by the mid-2000s the Penta state were already—relatively loosely—committed to cooperation in the field of power market integration provided an avenue to organise a dialogue about new fields of energy policy. When renewables policy implementation accelerated after 2011, the established mode of cooperation in the Penta Forum could frame the conversation about renewables policies and grid planning to adjust to the challenges of the energy transition. It not only helped to harmonise national policies but also enabled the Penta states to cooperatively adjust EU policies to their common regional situation. In addition, from a EU perspective this regional setting served as a “policy laboratory” for future EU measures and governance mechanisms, mainly because rules and standards that were developed in the Penta Forum emerged in the context of the EU legal framework (Szulecki 2016, 545).

11.5.2 Constructing Differentiated Energy Policy Integration

The Penta Forum primarily addresses technical and administrative issues of electricity market integration. Yet, the increased use of renewables created further challenges, complicating the integration process, while at the same time demanding even faster progress. Therefore, the task to enhance the flexibility of regional power markets has also been included among the issues that the Penta Forum deals with. Together with the bodies of other regional groupings, this intergovernmental initiative has evolved as an significant player in the low-carbon transition. To fully comprehend the geopolitics of this development, it is important to keep in mind that this form of intergovernmental cooperation evolved within the framework of EU electricity and renewables legislation.

This contextualisation is vital for two reasons. First, the cooperation to attend to the effects of growing amounts of renewable electricity is embedded in a governance structure that steers the EU electricity market integration. This regional body has already become acquainted with the mode of cooperation and the measures that guide the implementation of technical aspects of market integration. In this sense, the further refinement of regional market governance to enhance the flexibility of regional markets can rely on the experiences that have been obtained in the context of liberalisation and market integration. Second, measures that are taken by regional bodies such as the Penta Forum have to somehow relate to the goal of harmonising national policies and eventually accomplish the internal energy market. The discussion of the legislative history to achieve a competitive internal market for electricity illustrated the difficulties that the European Commission faced in coordinating market liberalisation and integration measures.

Eventually, in 2006 the Electricity Regional Initiatives were founded and supported regional platforms, such as the Penta Forum. Overlapping regional markets arranged their cooperation according to suitable market designs and transmission standards. Subsequently, these regional groupings moved further to harmonise their market governance.

Manuel Mohr concludes that this kind of cooperation between groups of EU member states constitutes a form of differentiated integration. He describes the contribution of groupings such as the Penta Forum as a “two-stage” process of developing mechanisms of market governance. First, rules are initiated at an informal level. Subsequently, they are formally “endorsed” by EU legislation, as exemplified in the case of the Third Energy Package (Mohr 2011, 161).

Other authors also suggest applying the concept of differentiated integration to EU energy policy (Ahner et al. 2012, 249–272). Indeed, this concept helps to understand the evolution of European energy market integration. It emphasises patterns of so-called multi-speed cooperation that also occurred in other policy fields, such as the EU monetary policy, cooperation under the Schengen Agreement, and the EU defence and security policy. Cooperation among EU member states is differentiated vertically, concerning the level of centralisation, or horizontally, relating to the number of member states that participate in a respective policy field. These forms of differentiation are often the result of considerations by national governments that either do not wish to pool national competences or do not want to (fully) participate in a Union-wide approach—i.e. opting out.

The study of EU electricity legislation does not reveal signs that member states want to opt out of the common power market. Rather, existing national market structures, technical conditions, and the available infrastructure do not allow all member states to proceed at the same level of speed. In addition, neighbouring markets face similar challenges. Mohr rightly observes that regional integration is an intermediate step towards Union-wide harmonisation and can be understood as a temporary form of differentiated integration (2011, 161).

The fact that regional market integration has played an important role in informing subsequent EU legislation stresses the intermediate nature of this development. The regional initiatives emerged between the second EU electricity directive and the Third Energy Package. There is much evidence that the informal patterns of cooperation shaped the legislation of the Third Energy Package. Indeed, several provisions of the package can be considered as a legal recognition of a previously informally agreed mode of cooperation.

Two examples illustrate this interactive process. First, Article 6 (1) of the cross-border electricity trade Directive 2009/72/EC stresses the promotion of regional cooperation. It states that regulatory authorities should cooperate “for the purpose of integrating their national markets at one or more regional levels, as a first step towards the creation of a fully liberalised international market.” Furthermore, member states should “promote and facilitate the cooperation of transmission system operators at a regional level, including on cross-border issues.” This regional cooperation should thus “foster the consistency of their legal, regulatory and technical framework.”

Second, Article 12 of the network-access Regulation 714/2009 states that transmission system operators should first establish regional cooperation with the European Network of Transmission System Operators for Electricity (ENTSO-E) to elaborate network codes and adopt common network governance measures pursuant to Article 8 (1), (2), (3). Paragraph 3 of Article 12 states that the European Commission can define the geographical area that is covered by regional cooperation by “taking into account existing regional cooperation structures.” Hence, Article 12 incorporates the notion that a solution to complex technical policy matters can be better pursued regionally before a Union-wide approach is possible.

In addition, ACER coordinates regional and cross-regional initiatives that seek to achieve market integration. It monitors the work of the ENTSO-E and the progress of its EU-wide network development plans. On the one hand, ACER is functioning as an EU institution and contributes to the successful implementation of EU rules and policies. On the other hand, it is also an important connector between regional governance structures, such as the Penta Forum, and forms of sectoral governance. Hence, the Penta Forum is embedded in an incremental integration process that takes into account regional preferences and developments and values sectoral input.

This brief discussion of differentiation in the context of electricity legislation demonstrates that differentiated integration in the field of EU energy policy does not necessarily lead to an “opting-out” of further integration steps. Rather, differentiated regional approaches gradually enable the inter-regional integration of power markets and help prepare the conditions for a well-performing internal market for electricity. In this sense, the Penta Forum functions as an intermediary form of market governance that both implements EU legislation and contributes to the further refinement of the legal framework.

At the current stage of transforming the EU energy market, there is no appropriate level of governance that can simultaneously develop, implement, and coordinate all measures that have to be taken in the course of creating a competitive electricity market with high shares of renewables. National market designs need a regional intermediary to reconcile differences before plans can be made of how to establish and govern an inter-regional Union-wide market. The role of the Penta

Forum in this process is significant, mainly because the Penta states cover the geographical centre of the EU and constitute the economic core of the Union. Moreover, the structure of their “coordinative market economies” is very conducive to the promotion and deployment of renewables (Ćetković and Buzogány 2016). By instituting a functioning model of governance to achieve the interconnection and coordinated expansion of their electricity sectors, the Penta states set an example that can be studied by other governments with respect to economic and governance conditions, which facilitate the decarbonisation of power generation in a cross-border context.

The Penta Forum precludes geopolitical frictions that might lead to short-term inaction and, subsequently, derail further integration. It provides a valuable setting where a shared understanding of a common energy future can emerge and pragmatically transpose into structures of market governance. By creating an example of managing fruitful cooperation between its member states and neighbouring regions and by displaying ideational and socialisation force, the Penta Forum is at the core of the envisioned Energy Union.

11.6 Concluding Remarks and Recommendations

The introduction of renewables in the electricity sector has the potential to disrupt established relations within an economy as well as across borders. Renewables are not only deployed to contribute to the reduction of CO_2 emission, but are seen to present new opportunities for exporting technology and creating jobs. Furthermore, the use of indigenous renewable energy sources enhances a state’s security of energy supply in the case of high levels of dependence on imported fuels. There is an obvious incentive for states to view renewables policies as a particular national interest. Accordingly, tensions with neighbours are very likely, as they pursue similar policies to promote their renewable sectors under comparable geographic conditions.

This chapter demonstrated that by cooperating in a depoliticised setting neighbouring states can address challenges that necessarily occur in the process of the low-carbon power transition. The purpose of this chapter was to explain which role the Penta Forum played in facilitating the cooperation between several EU member states that are faced with the task of both implementing EU policies to integrate their electricity markets and balancing nationally determined decarbonisation policies.

The discussion showed that several external and internal events determined how the Penta states perceived the policy environment in which the large-scale transformation of the EU energy sector was unfolding. First, the enlargement of the EU between 2004 and 2007 led to a reconsideration of issues of energy supply and the dependence of gas imports from only a few main suppliers. Second, with the entry into force of the Kyoto Protocol in 2005 global efforts to reduce CO_2 emission gained momentum and resulted in more comprehensive EU energy and climate strategies and policy measures. Third, the decision by the German government to speed up its nuclear phase-out and accelerate the promotion of renewable electricity had considerable consequences for neighbouring economies.

Constructivist thinking helps to assess how such events change perceptions of the relevant states' energy identity. In the late 1990s, the integration of the electricity market was mainly presented as a further step towards economic integration among EU member states. Energy security and decarbonisation became more relevant during the first decade of the 21st century. Both concerns forced individual member states to reconsider their energy policies. This led to adjustments of their imagined energy future, which subsequently influenced their position in negotiations with other states. The process results in a new shared understanding of the situation. Finally, the need to deal with intermittent electricity cross-border flows from Germany added a practical necessity to negotiate mutually beneficial solutions.

By that time, the Penta Forum had already developed a depoliticised modus operandi to deal with highly technical issues of electricity market integration. The forum was able to facilitate the enhanced cooperation related to increased deployment of renewables. When the states adjusted their energy identities, their emerging common understanding of the regional energy future was embedded in pre-existing structures, which could guide further cooperation and continued to evolve with these new developments. Hence, the Penta Forum facilitates cooperative interactions, which is essential for reconciling national preferences and avoiding geopolitical conflicts in the course of promoting renewable electricity.

In the process of EU energy integration, regional cooperation, as exemplified by the Penta Forum, constitutes an intermediary step towards market integration. This form of temporary differentiated integration is necessary and helpful in accomplishing the common market for electricity suited for a low-carbon future.

The analysis of how geopolitical conflicts as a result of changing interests and perceptions can be avoided in the course of the renewables transition that this chapter presented only dealt with EU member states. However, the findings are also relevant for neighbouring states that are not part of a supranational organisation. The main lesson that can be drawn from the cooperation of the Penta states is the emphasis on the characteristics of this forum that convenes relatively informally at ministerial level. It allows the participants to build trust and deal in a depoliticised atmosphere with the emerging technical, economic, and institutional challenges of the energy transition. An essential prerequisite on the part of the participating states is the willingness to imagine their regional energy future as founded on cooperation. Their appropriately refined energy identities are the basis for a shared understanding that eventually results in norms and institutions, which enable cooperation on specific matters such as grid planning, network codes, and renewables policies.

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Part IV
Conclusion

Chapter 12
The Strategic Realities of the Emerging Energy Game—Conclusion and Reflection

Daniel Scholten and Rick Bosman

12.1 Introduction

This volume explores the geopolitics of renewables: what the transition towards renewable energy implies for interstate energy relations. The topic is surprisingly novel; energy geopolitics seems to be synonymous with oil and gas, while literature on renewables focuses on achieving the transition. Hardly ever does one see an account on renewables' geopolitical implications. In turn, the volume's objective is to establish a comprehensive overview and understanding of the emerging energy game, one that puts the topic on the map and provides practical illustrations of the changes renewables bring to energy geopolitics and specific countries. To this end, a novel analytical framework was constructed in the introductory chapter that moves from geography and technology to economics and politics. It also studied developments on three levels of analysis, represented by the three parts of the volume: (a) the emerging global energy game, winners and losers; (b) regional and bilateral energy relations of established and rising powers; and (c) infrastructure developments and governance responses. Focus was on contemporary developments and how they may shape the coming decades. It is now time to take a closer look at how the geographic and technical characteristics of renewable energy systems (re)shape strategic realities and policy considerations of producer, consumer, and transit countries and energy-related patterns of cooperation and conflict between them. This concluding chapter summarizes the core developments

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regarding the geopolitics of renewables, relates them to the expectations presented in the first chapter, and draws overarching lessons regarding challenges and opportunities countries face in securing an affordable energy supply in the emerging energy game. It also reflects critically on the effort undertaken in this volume and the field of geopolitics of renewables and rounds off with policy recommendations and research suggestions.

12.2 Revisiting Expectations

The introductory chapter highlighted fundamental differences between the geographic and technical characteristics of renewable energy systems and those of coal, oil, and natural gas. Renewable energy sources are abundant and intermittent; renewable energy production lends itself more to decentral generation and involves rare earth materials in clean tech equipment; their distribution, finally, is generally electric in nature and involves stringent managerial conditions and long-distance losses. These stand in clear contrast to the geographically fixed and finite nature of fossil fuel resources, their general reliance on large centralized production and processing installations, and their ease of storage and transportation as solids, liquids, or gases around the globe. In the analytical framework, we take these characteristics as points of departure in investigating how renewable energy systems take shape and what their economic and political implications might be. These characteristics led to four sets of expectations regarding the changes that renewables are likely to bring to the energy game.

First, a move away from oligopolistic markets to more competitive ones, i.e. a shift from strategic leverage of producers to many countries having leverage: efficient producers, large consumers, and countries able to render cheap balancing services. The dominance of oil and gas producers is furthermore eroding by risks of stranded assets due to decline in oil and gas demand. This also results in a shift in concerns about getting access to limited overseas resources, diversification policies, and strategic reserves to a strategic make-or-buy decision between secure domestic production and cheap imports, availability at the right time and price volatility, and access to biomass and more geographically bound renewable sources.

Second, a shift from a focus on centralized facilities run by major energy companies to decentralized modes of generation by a new and more varied set of actors (households, businesses, and communities), enabling new business models and local empowerment.

Third, the use of rare earth materials in clean tech equipment increases competition for access to these materials between countries that aspire to be industrial leaders in renewable generation technology.

Fourth, the electrification of energy systems implies (a) a regionalization of energy relations, i.e. a shift from global networks to regional grids due to long-distance losses in electricity transport and less global entanglements in the MENA and CACR; (b) a shift in focus from continuity of commodity supply to continuity of service supply, making control over infrastructure development, operations, and regulation (and in this way energy markets) even more urgent; (c) a decline in the possibility to target single countries to interrupt delivery due to a common interest in infrastructure operations (immediate cascading effects of any interruption); and (d) the de-diversification of transport infrastructure.

The expectations are derived from an abstract academic exercise. Parts I, II, and III of this volume richly describe how the transition towards renewable energy is unfolding and presenting new challenges to interstate energy relations. We may now bring them together and see which expectations are already observable and reflect on the relationship under study, using the analytical framework developed in the introductory chapter. Emphasis is on those implications stemming from renewables' geographic and technical characteristics, though we also acknowledge those that follow from the broader energy transition, e.g. struggles for industrial leadership.

12.2.1 Part I

The first chapters in this volume deal with energy geopolitics, both fossil and renewable, on a global scale. From these chapters, it becomes clear that the transition towards renewable energy systems acts as a force of creative destruction that implies major shifts in geopolitical dependencies. Energy forms a crucial economic input. Countries that were able to harness oil effectively were leading the last century. It is therefore plausible that countries able to harness new, renewable forms of energy will take center stage in the late 21st century. While the US, EU, and China are already positioning themselves favorably in this transition, given their strong presence in R&D, patents, and production of renewable energy technologies, countries with large fossil fuel reserves that are not able to diversify their economies are at risk of losing out. The chapters provide more specific insights regarding the four expectations.

The contributions in this part seem to underscore the expectation that the development of renewable energy sources will bring with it a more competitive energy system. This expectation is, however, taken more as a starting point than that it is actually studied in detail. The consensus is that renewables help to diversify energy sources and that all countries have access to one form or another, since renewables are available in different forms across the globe.

With regards to the second expectation, especially Chaps. 2 and 3 take note of the fact that renewables are able to operate in much smaller production units and thus lower scale levels than fossil fuels. Although they note that the jury is still out on what an optimal scale of such energy systems will be, they do present a much more distributed renewable energy system as a plausible pathway, enabling a (literal) empowerment of regions, cities, and even individual households unseen in the more centrally organized fossil fuel age. As such, they see in decentralized renewable energy a means to democratize access to energy, in which a larger number of less specialized actors might become involved in energy supply chains than is currently the case.

The rare earths issue figures prominently in this part of the volume and it is an important factor in painting a key role for China in the renewable age. The country currently supplies about 85% of global rare earth demand and is rapidly developing its downstream production capacity, taking crucial positions across the supply chain of renewable energy technology. As such, it will become almost impossible to side-step China in a clean tech powered future. It will be interesting to see how other countries cope with this reality. Industrial leadership in clean tech was discussed in all three chapters of this part. While Chap. 2 set the scene with its emphasis on creative destruction, the dominant picture of current fossil fuel net-importers being the winners and net-exporters as the losers of a transition to renewable energy respectively was nuanced by Chaps. 3 and 4. Net-importers may still retain heavy GDP dependence on oil and gas related industries, such as refining and distribution, while net-exporters can use a variety of strategies to stall the transition or reinvest their oil-wealth.

The fourth expectation of increased electrification is mentioned in passing in Chaps. 2 and 3. Smart grid technology is discussed as being crucial to develop more distributed energy systems and HVDC power lines are mentioned as an important interconnection technology. While distributed smart grid enabled renewable energy systems are rather new, with as of yet unforeseen geopolitical implications on a global scale, HVDC lines have similar geopolitical characteristics to interstate energy pipelines. New dependencies replace the old while the difference between electricity and oil and gas pipelines in this regard is still to be investigated in more detail.

12.2.2 Part II

The second part of the volume investigates the geopolitics of renewables from the perspective of four major economies poised to play a key role in the transition towards sustainable energy systems: the US, Germany, China, and India. The chapters take a country perspective but relate domestic motivations to their bilateral and regional energy relations. The countries show different interests for pursuing the energy transition. Whereas the US and Germany consider it more from a strategic (diversification) and industrial policy point of view, China relates it more to economic development and industrial policy, while India shares China's development objective, but positions itself more in climate leadership, having to import clean tech know-how.

With regards to the four expectations, it becomes clear from this part of the volume that renewables play a role in developing more competitive markets. All countries under study currently import significant amounts of energy and the switch to renewables provides them with an opportunity to diversify away from these dependencies. Chapter 6, however, also shows that renewables' intermittency can create tensions between countries. In addition, Chaps. 5 and 7 identify threats in the US lagging behind in the renewables race, the dominance of Russia in the nuclear industry, and the position of China in clean tech and vital resources. Chapter 8 does the opposite by showing how renewables provide opportunities to India.

Although we might have expected a prominent role for decentralized energy in this part of the volume, this dimension is largely absent here. Chapter 5 mentions in passing that decentralized sources could enable the development of smart grid infrastructure. Chapter 8 sees large opportunities for decentralized solutions, especially in places with poor grid infrastructure, which are still ubiquitous in India. However, the rural population seems to prefer centralized grid connected infrastructure, as this is perceived to be superior to decentralized solutions. In China renewable developments seem to take place in a quite centralized, top-down manner, with large scale hydro and wind parks in favorable conditions. Chapter 6, finally, notes the international challenges that renewables, decentralized or centralized, bring.

Rare earths play a role in Chaps. 5 and 7. For the US, China's dominance in rare earths production is seen as a threat to its position in renewables. For China, the key is not only to mine these resources, but government industrial policy also seeks to develop downstream processing, technology development, and energy production domestically. As such, China is positioning itself strongly throughout the clean tech supply chain.

The developments in the US, Germany, China, and India seem to underline the expectations that renewables induce electrification and regionalization of energy infrastructure. While the US is already highly interconnected with the Canadian electricity system, the authors identify opportunities for increased interconnections with Mexico. The potential of Canadian hydropower sources to balance fluctuating renewables supply could be explored further. At the same time, cyber security is identified as a potential threat with increased electrification. With a growing share of renewables in its electricity mix, Germany is already increasingly faced with grid issues. Neighboring countries are taking measures to control fluctuating input from German wind energy. At the moment these are mostly defensive measures aimed at protecting their energy systems from foreign disturbances. Developing more cooperative responses aimed at ensuring grid stability across regional electricity systems might be explored further. An interesting example of such regional cooperation is the Indo-Bhutan agreement for hydropower. In developing such agreements, management of infrastructure is seen as crucial. It seems that variability of renewables at the moment poses less of a problem for India, as the country is already experiencing (partial) black-outs on a regular basis. China provides a telling case of the crucial role of grid infrastructure, as it faces problems to connect large swathes of wind power to its grid and bringing it to demand centers. It is ramping up the roll-out of HVDC-lines. Furthermore, it has launched a vision for an intercontinental super grid, connecting energy systems globally to reap the benefits of variable renewables production and energy demand across the globe.

12.2.3 Part III

In the last part of the volume, the infrastructure and governance dimension of renewable energy systems are discussed, with examples of the potential of participative governance to contribute to the energy transition, the performative role of two competing visions for the future Dutch energy system, and the Pentalateral Forum. Combined, the chapters show nicely how energy systems are changing from the ground up, whether through microgrid or supergrid possibilities, and how this affects local, regional, national, and continental communities, infrastructure operations, energy policy, and energy institutions.

With regards to the competiveness of the energy market: in Chaps. 9 and 10 the distributed developments which are enabled by new renewable energy sources play a central role. They are not discussed in terms of making the energy system more competitive, but they are seen as a way to provide energy security on the local level. Chapter 11 argues that EU energy market liberalization rather than new renewables was key to break up existing oligopolies and develop a more competitive business environment.

These last three chapters focus in-depth on the new actors involved in decentral renewable energy systems. They identify a whole range of new actors, including households, entrepreneurs, and intermediaries, whose logics are at odds with the traditional centralized fossil and nuclear based energy system. Chapter 10 also discusses the new players involved in large scale offshore wind, a development which has a better fit with the existing centralized system, but still involves numerous actors foreign to the traditional energy system. The Pentalateral Forum, in which Germany, France, Luxembourg, the Netherlands, Belgium, and Austria informally discuss energy issues, such as interconnections and standards, is put forward in Chap. 11 as an interesting way of developing rather informal sub-EU-level energy governance. Because of its informal setting, it is proposed as an interesting way to deal with potential geopolitical frictions without politicizing them, which is deemed necessary to resolve new issues arising in the transition towards a sustainable energy system.

The issue of rare earths is absent from this part of the volume. Presumably it does not play a role when studying the more infrastructural and downstream related issues which are in focus here.

The fourth expectation of electrification figures prominently in part III. Next to growth of renewables, increased options for electrical heating and use of electric vehicles are identified as drivers. Chapters 9 and 10 both identify centralized and distributed pathways for renewables. They propose that while these pathways are generally disconnected at the moment, there is ample opportunity for mutual benefits, with distributed smart systems with a centralized backbone as a promising venue. Chapter 9 also highlights the crucial role of infrastructure management in such a system and shows how China is already positioning itself to take a leading role. Chapter 10 shows that offshore wind development indeed provides opportunities for more regionalization, meshed infrastructure, and cross-border cooperation with other North Sea countries. Actual developments, however, at least in the Netherlands, are predominantly national. Furthermore, the difficulties encountered in developing international meshed infrastructure might underscore the importance of control over grid infrastructure. In this light, opportunities for new businesses in providing flexibility are identified. Regionalization of energy relations figures prominently in Chap. 11: the Pentalateral forum is seen as a welcome first step towards EU-wide harmonization.

12.2.4 Discussion

Looking at the chapters in light of renewables' geographic and technical characteristics and related expectations highlights a number of general observations regarding the core relationship.

Changing dependencies, but less tensions

Renewables hold the promise of a brighter energy future. They have the potential to relieve many fossil fuel related tensions, such as import-dependence, GHG emissions, and the need to secure primary energy reserves and trade routes. However, this volume has shown that we cannot expect a renewables powered future to be free of challenges. Renewables put pressure on countries' energy systems from above and below, through changing global energy markets and dependencies on the one hand (Part I) and changing infrastructure (governance) on the other (part III). How countries strategize on these developments in light of national interests has been discussed in part II. In all, it is likely that renewable energy implies a commodification, not politicization, of energy trade. Renewables provide new possibilities for energy production and less geographically determined dependencies, but may well make energy relations more complex due to the inclusion of new actors and business models and the managerial demands of electricity. We believe two core characteristics stand out: renewables' abundance and electric nature.

While in the traditional fossil based energy system, security of supply of relatively scarce primary energy resources is the main issue, renewables are in principle abundantly available, but their supply is variable. As the energy transition progresses, a growing number of countries produce more and more energy domestically or become net-exporters, shifting the challenge from getting access towards reliable energy service, i.e. balancing a system that has both variable demand and supply, including (seasonal) storage, and a key focus on grid infrastructure and its management. This is not to say that access to scarce resources disappears as an issue in an energy system dominated by renewables. It does play a role when it concerns rare earth minerals and geobound renewables. While these minerals might form a bottleneck, it should be noted that it concerns input for a piece of technology, which when installed produces energy for several decades. As such, it is a very different challenge than securing a constant flow of energy commodities, which is the case in a fossil fuel dominated energy system. Nevertheless, geographically bound renewable sources such as hydropower or biomass will retain access issues as not all countries have access to them.

We observe plenty attention for electrification of the energy system in the volume. As of yet it is unclear whether this underlines our expectation that the energy system will increasingly electrify, or whether current renewable energy developments mostly take place in the electricity system, and heat and mobility will follow later on in the transition. Still, if electricity will play an increasing role in the future, the question becomes how interstate electricity trade will differ from pipeline connections in terms of its political implications. For starters, it is likely that interstate grid management becomes an issue, which we already see happening in the Indo-Bhutan agreement for hydropower or the difficulties encountered in developing a common North Sea grid. Moreover, although it might be possible to develop global electricity grids, as envisioned by the Chinese global supergrid plans, the losses incurred with transportation, imply that there might be limits to an optimal grid size, influencing the geographical span that will be interconnected. At the moment this limit lies at 3000 km before losses render it uneconomic (see Chap. 3). Furthermore, the complexity and strategic interests involved with interstate grid management arguably makes countries quite picky with whom they want to interconnect their grids. This might lead to the emergence of grid-communities between ‘trusted’ countries which have developed integrated energy systems and reliable governance of these systems.

Shifting dependencies also imply shifting fortunes; some countries are poised to gain from the transition towards a renewable energy system while others lose out. Those countries which are able to capture part of the value chain of clean energy systems are set to win. China is mentioned as very strategically developing up- and downstream clean tech activities. However, what we did not see in this volume is that countries which are blessed with abundant renewable energy resources, such as those located at 30° North or South of the equator where solar irradiance is highest, or those blessed with large biomass resources, or windy locations, might be winners. Moreover, the expectation that those countries that are favorably equipped for infrastructure management or balancing power, such as those with suitable geography and water supplies to develop pumped-storage hydropower basins, might gain an important role, cannot be empirically verified yet. It seems clearer, though, that the losers of the transition are those countries blessed with ample fossil fuel reserves and that bet on these resources for too long, without developing alternative economic activities.

Phases of transition

Sustainability transitions literature suggests that socio-technical transitions, such as the energy transition, go through different phases, each with their own dynamics. The chapters in the volume seem to underline this view as some expected challenges are already visible while others (far) less so. This also raises questions about what we did not see yet: is it just a matter of time before we see it, is the expectation wrong, or did we simply miss it.

We can, for example, clearly observe countries positioning themselves in the clean tech race or worrying about stranded assets. The increasing number of clean tech related trade wars, mostly between US/EU and China, and shifting investments from oil to renewable energy underline that countries acknowledge the economic interests involved. Claiming a 'piece of the pie' early on is likely to make sure that they will be part of this bourgeoning sector. In a similar vein, the use of renewables as a source of diversification to level the playing field with current oil and gas producers, is clearly visible. Of other issues, we see early signs of things to come. We start to see that renewables induce new business models, actor constellations, and institutional rules of the game regarding infrastructure management. As these are still in the making, initiatives are faced with a high degree of complexity and uncertainty, and the final forms have yet to materialize. The same goes for access to rare earth materials. Countries worry, but widespread action has yet to be undertaken. The intermittency issue is an example of something we have seen less. It seems that it is considered something of a technical issue which can be solved in more informal arenas. Even though part III and Chap. 6 evidence cross-border irritations due to electricity production peaks, it does not yet really figure as a strategic concern in interstate energy relations in the larger scheme of things. Nevertheless, only time will tell whether the transition towards renewables makes availability at the right time a geopolitical concern or a technicality that will be dealt with, either by continental interconnection or by countries insulating themselves from foreign peaks. Other things are matters that we did not really see yet, but can be reasonably certain of that they will be so at a later stage: the shift in emphasis from getting access to energy reserves to the regionalization of energy trade. It is likely that electrification has not yet progressed sufficiently enough. An example of something we did not witness and might never do so would be concerns over cut-offs in an interconnected electricity grid or efforts to get access to geo-bound renewables. Finally, other issues show disagreement among even the contributors to this volume. Throughout the volume different authors touch upon the issue of global trade patterns and how the growth of renewable energy influences these. Some authors argue that global trade in fossil fuels will be replaced by that in renewables. Others, including the authors of this conclusion, think that renewables will reduce the volumes shipped across the globe significantly.[1]

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[1] Fossil fuels know global trade in primary energy resources (coal, natural gas, crude oil), production and processing facilities (power plant, drilling rig, refinery, etc.), and secondary energy sources (electricity, heat, hydrogen, gasoline). While crude oil and natural gas are two of the top three commodities traded globally (see Chap. 5), for renewables we do not expect large trade volumes of primary energy sources. Renewable energy installations need not be continuously fed by resources that are traded. The wind and sun are free goods available across the globe and are harvested close to where they are needed. There is little need or ability to ship these. For biomass, a similar argument can be made: because of the generally high water content of this fuel, it is best used close to the source. The same goes for geothermal energy, which is produced in the form of heat. With decentral generation of renewable energy sources, one might expect that global trade in

In summary, while it has proved a very fruitful exercise to scope the geopolitics of renewables, it is too early in the shift towards renewable energy systems to verify all the expectations outlined in the introduction. The importance of the geographical and technical characteristics of renewables and their differences with traditional fuels figures prominently throughout the volume, but some of the economic and political implications derived from them do not play out so clearly yet. In this light, we may well conclude that thus far renewables are changing interstate energy relations more through their expectations rather than their actual impact in the energy mix and by relieving fossil fuel related tensions, not (yet) through their own challenges. In addition, even if renewables already affect energy markets as a commodity inducing creative destruction, the more fundamental ways in which we expect renewables to shape a new topology and operation of global, regional, and domestic energy systems due to their abundance and electric nature cannot yet be observed in the actual energy geopolitical arena.

Issues of scale and perspective

The volume has been structured along three levels of analysis, the global, bilateral/regional, and infrastructural. The issues observed at these levels differs. For example the rare earths and clean tech industrial leadership issues figure prominently on the global and regional level, but are absent on the infrastructure level. In contrast, the issues of distributed renewables and electrification induced grid management figure much more prominently on the infrastructure level than in parts I and II. This raises the question whether different issues play out at different scales or whether how and where we look influences what we see.

Most research on energy geopolitics takes an international relations perspective, putting interstate energy relations in its main focus with countries as the unit of analysis. Such a lens is quite effective in identifying issues of power and politics and the challenges faced by policy makers working on (future) energy. However, because the transition to a renewable energy system is still generally in its infancy, a lot of potential issues may not yet have entered the global, regional or even national level. Therefore, the infrastructure (part III) provides a key part of the puzzle. In this part, more concrete cases of renewable energy initiatives and their implications for governance feature, such as the involvement of a more varied set of actors. Studying decentral systems provides crucial insights on issues which might enter national, regional, and global political agendas, as these systems grow in scale and reach. Furthermore, while an international relations perspective tends to focus on

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production and processing facilities might go up. To produce the same kWhs, many solar panels need to be installed as opposed to a single coal-fired power plant. However, their total trade value may end up being roughly equal, taking all material suppliers and maintenance also into account. With regards to trade in secondary energy sources, due to increases in decentral production the amount of electricity traded and shipped is likely to decrease, unless local trading within communities takes off (in which case trade is also more geographically restricted). In sum, in our view, the need to ship or pipe primary energy resources will be reduced significantly. It will also not be replaced by shipping generation technologies or trade in secondary energy resources.

the interstate issues arising from energy production, transmission, and use, part III shows that because renewable energy bears the potential to develop more decentral energy systems, its geopolitics might also become more local, directing attention towards intrastate geopolitics. This might concern issues over e.g. land (and horizon) use, distribution of benefits and costs of local energy resources, and location and management of grid infrastructure. As such, part III underscores that instead of a mere diversification of resources, the geotechnical differences of renewables versus their fossil fuel counterparts imply a disruption in energy systems, business models, and institutional designs of energy markets. When renewable energy systems scale up in the next decades, we can expect such issues to become more prevalent.

Context

A last issue to be discussed is whether the way renewable energy systems are taking shape is driven by their geographic and technical characteristics or by exogenous factors. While we find evidence that these characteristics play a role, especially on the intrastate level, where renewables are developed in places where renewable resources are most readily available, the countries where renewable energy systems are most developed, are not necessarily those countries endowed with most renewable resources. Rather, at the moment the most important drivers for countries to take a progressive role in the energy transition seem climate and industrial leadership. The EU, China, and India see leadership in global climate negotiations as a way to claim their role in international politics and thus gain global prestige. Now that the US is rethinking its role, they see opportunities to fill gaps. Furthermore, the most progressive countries on the renewables front are current importers of fossil fuels, using renewables as a way to diversify their energy supplies. It can be argued that at the moment interstate energy relations are shaped more by these developments than the geographic and technical characteristics of renewable energy systems. On the other hand, it remains to be seen in how far these drivers will actually shape the play of the energy game in the long run. These drivers push renewables as such, but do not show how renewables, once pushed, influence energy systems and geopolitics in return. Once the transition to renewables is sufficiently underway, we may certainly expect that renewables acquire a dynamic of their own. Increasing electrification and renewables' abundance are bound to leave their mark on energy geopolitics. At this point, however, it can be difficult to separate the geopolitics of renewables from those of energy and climate change.

12.3 Implications for Theory and Practice

Above we treated the changes in energy geopolitics that renewables bring. With that, the volume provides what it aims for: a comprehensive overview and understanding of the geopolitics of renewables. It is now time to discuss the conceptual and policy implications of this.

12.3.1 The Field of the Geopolitics of Renewables

This volume introduced a specific perspective on and analytical framework for the geopolitics of renewables, basing itself on literature on international relations, (energy) geopolitics, and energy security on the one hand and renewable energy technologies, energy economics, energy transitions, and energy policy on the other. The findings regarding the expectations allow for some interesting feedback on the field of the geopolitics of renewables as well as its source material.

This volume contributed to the study of the geopolitics of renewables in several ways. For starters, it provides the first proper introduction to the geopolitics of renewables, one that scopes a new phenomenon. It offers a comprehensive overview of the main global, regional, and infrastructure challenges and illustrates these with examples, providing practical insights and an accessible read for policy makers and other practitioners. This puts the topic on the map and emphasizes the need to research and debate it.

Second, the volume provides a literature review that serves as a convenient summary of this novel field and that defines core concepts and their relationship in a simple yet effective manner. The definitions break new ground by positioning renewable energy as socio-technical systems, building upon the notion of the geo-technical ensemble, and focusing on the perspective of geopolitics as the one-directional way in which renewable energy systems influence interstate energy relations. The perspective of energy systems as socio-technical systems enabled the inclusion of the much-needed infrastructure (and governance) component. While the infrastructure level might seem strange from a traditional energy geopolitics perspective, dealing with microgrids and supergrids, regionalization, and electricity's managerial requirements has actually shown their importance for fully understanding renewables' implications, and highlights this unjust neglect by the energy geopolitics literature. The straightforward definition of geopolitics allows for a clear dependent and independent variable, setting up a structured line of argumentation. Taking the geographic and technical characteristics of renewable energy systems as the point of departure is what sets our framework of analysis and this volume apart from those accounts that essentially write on energy politics, though it may be criticized by those familiar with the various meanings and aspects of geopolitics.

Third, the analytical framework represents an easily applicable, step by step approach to understand the geopolitics of renewables that allows for a rigorous, empirical research agenda. Its analysis is notably different from more constructivist, holistic, or often lengthy historical narrative driven accounts. The geographic, economic, and political steps do not only carve up a complex relationship into manageable pieces, but also allow for a careful operationalization and positioning of relevant factors, and for a clear difference between the core relationship under study and contextual factors influencing it. It also allows for existing theories and insights to be applied in conjunction with it, under its broader umbrella. Taken together, scholars and practitioners are presented the means to explore and compare the political implications of a specific (set of) renewable energy source(s), also within various scenarios.

Finally, a last lesson stems from the difference made in this volume between the implications for interstate energy relations from renewables' geographic and technical characteristics and the broader transition towards renewables, as addressed in Chap. 1, Sect. 1.2. On the one hand, the focus on renewables' characteristics is what makes this volume and our framework truly about the *geo*politics of renewables. On the other hand, this volume also shows that an exclusive emphasis on these characteristics as a point of departure would have ignored important aspects that shape energy geopolitics, like industrial leadership ambitions or the oil end-game, which are implications of the transition towards renewable energy. While this volume worked around this issue by positioning it as being interested in all implications of a transition to renewable energy in general but those stemming from the geotechnical characteristics in particular, the matter is far from resolved and deserves further attention if the field of the geopolitics of renewables is to be defined clearly.

When it comes to the source material, the concept of energy security, the field of energy geopolitics, and the discipline of international relations benefit in three basic ways. First, the volume expands the fossil fuel orientation of energy geopolitics with a renewables dimension, enabling a comparison between the political impacts of a more varied set of energy sources. The novelty of the topic stands in contrast to the increasing relevance of renewables in energy geopolitics. The field of energy geopolitics can certainly direct more attention towards understanding the impact of renewables on interstate energy relations, even at this point where the share of renewables in the global energy mix is still relatively low. We believe the volume has provided sufficient proof of that. Renewables, whether directly affecting infrastructure operations, energy markets, strategic thinking, or via the expectations that an ongoing energy transition evokes are influencing energy foreign policy making today.

Second, the benefits mentioned above regarding the field of geopolitics of renewables, can be considered equally valid for energy geopolitics, especially if the former is perceived as a sub-field of the latter. The definitions, the framework, and the levels of analysis pose interesting additions to the study of interstate oil and gas relations as well. They not only seem readily applicable, but could even provide a structured approach to the subject.

Third, it is also interesting to see in how far the current terminology of energy geopolitics in general and energy security in particular can capture the new challenges renewables bring. While some renewable specific challenges clearly fit existing energy security dimensions, e.g. getting access to rare earth materials or (cyber) threats to infrastructure assets, others are not. More attention should go to these challenges and their inclusion in the energy security lexicon. Think for example about adding availability at the right time and efficient and sufficient electricity storage means as part of security of supply. Other examples would be a more explicit inclusion of the difference between the managerial requirements of operating oil, coal, natural gas, and electricity infrastructures and the level of commitment by policy makers regarding investments in renewable energy production capacity and modernization of distribution networks. Other things, in turn, might be excluded: existent environmental concerns become less relevant for renewables (though local pollution does not disappear). While the dimensions of energy security do not require a complete rethinking, they could certainly benefit from an update with challenges renewables raise. In a somewhat different way, one may also ask about the relevance of established notions such as consumer, producer, and transit states or the resource curse in a future where countries are essentially prosumers and energy may no longer be the global commodity that oil is today.

The contribution of the volume to energy geopolitics and energy security is not matched by a similar contribution to energy systems, energy transitions, and renewable energy technology literature. The focus of the volume has been on the political implications of current developments, not on bringing about a desired end-state or a detailed study of the transition process thereunto. For example, the volume does not offer new insights into the type of transition process that may be expected (substitution or transformation pathways etc.), whether IEA and IRENA predictions are more or less accurate, what technologies are most likely to have major breakthroughs, or how decentral and central renewable options should be integrated. Nevertheless, the volume's focus on cross-border effects of national, even local, infrastructural developments could give an impulse to the transition literature to do the same. Transitions tend to be studied in a national sector based case-study setting, with limited attention to interactions with and implications for neighboring countries. In addition, while transition literature is familiar with the winners and losers jargon when discussing the actors involved in a transition, it does not do so on a country level. It does not try to identify, as Chap. 3 does, what the possible key factors are in shaping these winners and losers.

12.3.2 Policy Recommendations

The interplay between the geopolitics of fossil fuels and renewables is going to shape the energy transition and the policy space for countries in the next decades. To derive policy recommendations, we should first discuss the likely role of renewable energy in energy geopolitics at various stages of the transition.

In the short term, renewables mostly alleviate geopolitical tensions associated with oil and gas, while industrial leadership in clean tech challenges energy relations. In addition, there is a domestic attitude to the energy transition by countries in this early phase of the transition. The two core drivers for the energy transition are reducing harmful emissions to avoid climate change related risks and providing current net-importing countries with the means for diversification to avoid dependence on oil and gas exporters and related energy security challenges. Concerning the latter, renewables relieve geopolitical challenges consumers face, though they increase anxiety over stranded assets in exporting countries and oil and gas companies. While the installed capacity of renewables is growing fast, rising global energy demand prevents the effects from renewables' abundance to be a strategic factor thus far. Of greater urgency is the already ongoing competition between countries for industrial leadership in clean tech. Any ambitions for industrial leadership in renewable energy generation technology (or for leap-frogging) are now to be decided. By and large, most countries still retain a domestic focus when it comes to the transition towards renewable energy. Policy attention is oriented towards stimulating investments in renewables, finding a good balance between central large-scale renewable projects and local-bottom-up developments (technology choice), and the accommodation of new actors. The intermittency of renewables is slowly becoming a nuisance in areas of high renewables penetration, mostly because electricity grids and energy systems and markets have yet to respond to these developments. The same can be said of decentral generation and rare earth materials; the system integration of decentral generation requires attention (even though its share in the energy mix is still too low for local grid operators to fear large-scale blackouts just yet) and the demand for clean tech is not yet pressuring material limits, but is already worrying policy makers. While relevant things to think about, policy makers should not ignore looking further ahead and devising a long-term strategy about their country's role in a possible continental supergrid in general and tactics for developing domestic sources and ensuring interstate balancing and interconnection capacity in particular.

The medium term is the most difficult to estimate. Rising demand implies the use of large amounts of both fossil fuels and renewables while infrastructure topology and operations adapt to new renewable technologies and novel actors. In other words, energy abundance depoliticizes markets while grid developments make energy relations more complex. Assets are getting written off and investments are directed towards renewables, the abundance makes for competitive markets but the distinction between producers and consumers remains. Producers try to use their financial reserves to continue their role in energy production or invest in other capital-intensive sectors. Consumers will try to stimulate their production and industrial leadership. Choices in the previous stage for a specific mix of central and decentral generation, political consensus on national development priorities and capacities, and the activities of other countries will shape the new energy map. Solutions to intermittency will have been put in place, either through storage, grid reinforcement, smart grids solutions, spatial interconnection, market mechanisms, etc., and the system integration of decentral renewables and new business models in energy markets is underway. In terms of industrial leadership, emphasis shifts from producing high-tech generation equipment for renewable energy enthusiasts by frontrunner companies to more mass-market products to accommodate a rapidly expanding market; it's all about capturing sales and market share in an increasingly competitive sector with many new entrants. If rare earth materials are part of these technologies, the scramble for these will now be at its most intense. If the previous stage was about technology choices, this stage is about infrastructure choices. Continental interconnection is forming a supergrid and flexibility or long-term assurances are key to security of supply. The former requires sufficient domestic capacity, the latter mutual benefits or dependence, or better yet, ownership and decision rights with regard to cross-border infrastructure assets and operations and the capacity to enforce those.

In the long run, once renewables dominate the energy mix, the issues mentioned in the expectations may materialize, i.e. competitive markets with no clear distinction between producers and consumers, a shift from a focus on security of commodity supply to service continuity with supergrid politics replacing pipeline politics, and a move from global to regional energy cooperation. Concerns shift from access to overseas resources, diversification policies, and strategic reserves to availability at the right time, availability of rare materials, and a strategic make-or-buy decision between secure domestic production and cheap imports. The distinction between producers and consumers is blurred, creating essentially only prosumer countries, but remains very real for the few countries unable to service a strategic amount domestically. Transit countries lose relevance but countries offering cheap storage gain. In general, energy is commodified instead of politicized, due to the possibility of more freely selecting countries to trade with, rather than having to trade out of bare necessity. In turn, the focus on continuity of service shifts emphasis in the energy game to grid communities and grid politics. A likely result, following International Relations literature, will be few trade relations between great powers to avoid dependencies (a balancing strategy), a choice for smaller countries within supergrids/grid communities to bandwagon with the great power or opt for more self-proficiency depending on the trust in their great power partner to honor its agreements, and a choice for the local great power to be a more benign hegemon, providing energy infrastructure and services for obedience in political matters, or not, using the supergrid as a form of domination. Clean tech will be generally installed as the market is saturated, leaving only demand for replacements not expansion. This also implies fewer tensions around rare earth materials, as their demand drops as well. Many of the technical issues regarding intermittency or the system integration of decentral generation and microgrids will have been taken care of. New energy security challenges at this point would be an overreliance on a handful of specific renewable sources, i.e. a lack of diverse sources, now that oil and gas are being phased out or serve as backup power/strategic reserves, and the reliance on electricity as the main energy carrier, essentially de-diversifying transportation.

This sketch of the energy transition clearly shows that it is already time to think about how to make money out of the energy transition and that it is prudent to clearly develop a longer-term strategy for energy foreign policy.[2]

Of immediate importance to countries at this point is to analyze whether and how revenues can be generated from the transition to renewable energy and to decide upon any ambitions regarding industrial leadership. This not only holds for clean tech, but also other areas of the supply chain: generating income by selling/exporting electricity, through the ownership of (international) grid assets and providing transportation services, or by offering balancing (storage) services. Countries would do well to investigate where their competitive advantage is or can be developed. There are many possibilities here. Just looking at clean tech, for example, we can see that options differ per renewable source, per generation technology and the materials used, per step in the supply chain (e.g. constructing offshore wind parks requires expertise in laying the foundation, the turbine, etc.), and per supporting industries such as financing and logistics. Not deciding upon ambitions now clearly risks becoming a laggard, and not frontrunner, in the sector.

Countries also need to investigate their likely role in future energy markets. Will they be a net-exporter or a net-importer and is there a possible role as transport hub or storage facilitator? Even though the distinction between producers and consumers will increasingly blur, domestic capacity to generate renewable energy will still differ between countries and determine how much freedom a country has regarding the make-or-buy option. Related to this positioning is also the question how energy security is to be attained: via isolationist policies or via continental interconnection? What balance between decentral generation, central generation, and imports is desirable and feasible? What would be a fruitful and attainable position in cross-border asset ownership and operational decision rights? Moreover, next to domestic capacity, the presence or absence of reliable import partners and political and economic capabilities of oneself and trading partners play a crucial role.

A final matter for countries to investigate is the energy security effects of the domestic and global transition to renewable energy. While investigating all the mentioned dimensions is advisable, with regard to interstate energy relations an assessment of new dependencies is most relevant. With whom can we reliably interconnect grid infrastructure and trade; where should we import rare earth

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[2] As stated in Chap. 1, we assume that consumer countries are concerned about security of supply and desire stable and affordable energy prices, that producers want to maximize energy revenues to fuel their economy and desire security of demand, and that transit countries are essentially interested in retaining their position in the infrastructure in order to extract a fair rate for their services and to create some political leverage for themselves (sitting at the table).

materials from; how can we compensate for the lack of strategic reserves? Acquiring a prominent position in cross-border infrastructure management could go a long way in securing affordable energy that is available at the right time.

12.4 Limitations of the Volume

With the discussion and interpretation of findings completed, some critical reflection on the volume is in order. There are a number of issues that deserve attention.

The most important limitation of a volume that tries to discuss future implications of contemporary developments is the sensitivity of the conclusions. Political developments, such as the fall of the Berlin wall or the Paris agreement on mitigating climate change, or techno-economic breakthroughs, like the shale gas revolution or cheap batteries, are hard to predict and can have significant impact on energy geopolitics. Indeed, many findings of this volume are better interpreted as most likely occurrences. In many ways, the separation of the analytical steps of the framework from the last, contextual step, is testimony to the fact that while we may reason in a ceteris paribus fashion the consequences of renewables' characteristics for interstate energy relations, one should always invoke various scenarios to see how exogenous factors may influence the relationship. Some of the biggest uncertainties in this regard may well prove to be the actual speed of the energy transition or just how much of global primary consumption can actually be met by renewables. Even though technology is developing at a breath-taking rate (looking at the efficiency gains in solar and wind or new applications in geothermal, tidal, and wave energy), the use of biomass could prove essential to meet global primary energy consumption by renewables. This, however, is likely to raise new (sustainability) challenges on its part…

Second, the volume has an imbalanced focus on a number of fronts. Most notably is that not all renewables have featured equally in the volume. It seems biased towards solar and wind, and other renewables whose transport is generally electric in nature. Biomass, for example, was mentioned on few occasions. The same goes for hydropower and geothermal sources, the more conventional renewable sources. Instead, we saw a discussion on nuclear. While seemingly misrepresenting the geopolitics of renewables, it does suit the energy transition focus. Solar and wind are simply changing the sector while we speak, while hydropower and geothermal are well-established in the electricity mix. As we focused on the changes that renewables bring, such a bias may be considered warranted. Related to this, is the volume's focus on electricity, with little direct attention to mobility, heat, or various gases in a predominantly electric future. A next study should focus more on power-to-gas, hydrogen fuel cell vehicles, district heating and cooling, etc. At this point one may critique this volume for mostly being about "the geopolitics of renewable *electricity*". Another bias regards that not all expectations featured equally in the volume. Certain sub-categories mentioned in the introductory chapter, like local spatial conflicts and cyber security threats, received limited attention. This should not be seen as an indication that we deem such matters less relevant. On the upside, we did also not encounter many items not mentioned in the introductory chapter. The list of expectations seems rather comprehensive. A last bias concerns the selected countries in the second part of the volume. Why not an exclusive chapter on Japan, Russia, or Brazil, for example? Sub-Saharan Africa, Australia, and South-America also hardly feature. Moreover, the four selected countries are all current net-importers. One reason is that the purpose of the volume was to showcase the most important changes that renewables bring, not to be exhaustive in terms of country scope. Another reason is that Chap. 4, with its focus on current net-exporters, largely handles the producer side of things. Nevertheless, investigating more cases never hurts, especially if they show notable differences from the experiences of the countries treated in this study.

Another limitation is the rather strict interpretation of geopolitics with its focus on the geographic and technical characteristics of renewables as point of departure and interstate energy relations as the dependent variable. The volume did not, for example, discuss the opposite: how energy geopolitics influences the transition to renewables and/or the shape of renewable energy systems. It also does not investigate other geopolitical perspectives beyond the narrow definition, like that of critical geopolitics, or the role of agency and human interpretation of a changing environment in shaping developments? Such avenues are waiting to be explored. Finally, the strict interpretation was somewhat at odds with the objective to establish a comprehensive overview of renewables' implications for interstate energy relations. We already discussed in Chap. 1 the necessity to compromise between a more conceptual focus on renewables' characteristics and the transition to renewable energy so as to include more current developments in scoping this new field. The definition, however, suits the objective of the volume, because its narrow nature helps provide a structured overview and understanding of the emerging energy game, and fits the novelty of the field, as its simplicity provides accessibility to a broad readership, including practitioners as well as academics.

A fourth limitation relates to the volume's structure that accentuates the importance of the three levels of analysis to fully capture renewables' implications. Other options to structure the empirical parts would have been along renewable energy technologies, e.g. solar PV or biogas, renewables' characteristics, e.g. abundance or electric nature, or (sub)set of expectations at a time. This brings more analytical clarity and depth of the impact of individual technologies or characteristics on interstate energy relations at the cost of a focus on their combined effect and a more country oriented narrative of how states perceive and handle the energy transition. Moreover, a technology specific focus would have led to much repetition regarding their similar implications. More closely analyzing the geopolitical implications of specific renewables' characteristics or related expectations is what we consider as the logical next step for the field now that an overview has been established. Going more in-depth this way would have gone beyond the objective of this volume, i.e. putting the topic on the map, and would have ignored the novel status of the field, one where definitions, theories, frameworks, and even the justification of studying the particular characteristics are absent, among other considerations. By using the current structure for the volume, we have managed to avoid these pitfalls and provide a more practically relevant overview.

A final limitation is that by and large the volume has emphasized the challenges that renewables bring rather than the challenges they solve. The role of renewables as means of diversification and harmful emission prevention is well-known, of course, and need not deserve too much attention in this volume. Yet, now that we come to the end of this volume, it does not harm to stress this aspect again. While new dependencies replace the old, it seems that energy relations are about to become more complex, but less prone to geopolitical tensions. In this light, it may also be noted that the focus on the challenges that renewables bring has limited attention to the institutional or governance responses to handle them. Only part III has actively sought to provide governance suggestions to the deal with renewables' challenges. Such suggestions, however, are still waiting to be developed for the global and regional level. What institutions are required to mitigate strife over renewable energy production and distribution? What role for global energy governance and international institutions?

12.5 Rounding Up and Looking Ahead

The Geopolitics of Renewables is the first volume to specifically explore the geopolitical implications of renewable energy; a novel topic that has gone under the radar for too long. The energy transition is picking up speed and it is time to think about its broader implications. No longer is energy geopolitics the exclusive domain of oil and natural gas; renewables are influencing investment decisions and energy flows today. Moreover, renewables are a game changer due to their different geographic and technical characteristics as opposed to fossil fuels. This volume provides a comprehensive overview and understanding of current developments and their (future) implications for countries and the energy relations between them.

This volume should not be seen as the definitive work on the subject. Quite the contrary, it represents a first discussion of a new phenomenon, putting it on the map and inviting others to contribute to the field. We are only at the beginning of the transition to renewable energy after all! New research directions are plentiful, hence whether in terms of topics or sharpening theoretical underpinnings. The volume is hence better seen as an introduction that takes stock, scopes, and teases, i.e. tries to stimulate the many works that are sure to come over the course of the next decades. It is an invitation to all that wish to join the growing community investigating the geopolitics of renewables. Our last comments should be seen in this light.

The energy transition holds the promise of a brighter future, but it is not free of conflict potential. While new challenges replace the old, the changing nature of the game suggests less energy related tensions. The emerging energy game entails a commodification, not politicization, of energy trade. Renewables leave more options for countries, less critical dependencies, though energy relations are likely to be more complex. A summary of the main similarities and differences between the geopolitics of fossil fuels and renewables illustrates this nicely.

Similarities can be found in new dependencies replacing the old: the need for access to biomass and raw materials instead of oil and gas sources, HVDC interconnection instead of pipeline politics, and new industrial leaders in clean tech instead of current major oil and gas companies and associated countries. All of these new dependencies seem weaker than the old, e.g. once sufficient generation capacity has been installed, little energy needs to be imported, more meshed interconnection allows for rerouting and more trade partners, and market power is not restricted to resource rich countries.

Differences can be found in the nature of the game. The merging of producer, consumer, and transit countries into a collection of prosumer countries—that can to a greater or lesser extent source their energy needs domestically, export or import excesses or shortages via a continental grid, or can provide balancing services—broaden country options to secure an affordable energy supply. The electrification of the grid combined with the emergence of microgrids and supergrids, with their various new actors, limits critical junctures and classical transportation corridors, opens new market possibilities, but also raises managerial demands for cross-border coordination. More competitive markets and frequent interactions between regional neighbors suggest less opportunistic behavior and conflict potential.

Of course, these benefits do not give any guarantee that the transition thereunto will be smooth. A global and regional reshuffling of alliances creates a great deal of uncertainty, something generally associated with settings prone to conflict. The same holds for domestic power struggles that result from the global and local introduction of renewable energy. Hence, while renewables alleviate geopolitical tensions for now, it is prudent for countries to prepare for the challenges ahead and further investigate the possible geopolitical implications of the energy transition and potential strategies and policy tools to respond.

The different characteristics of renewables vis-à-vis fossil fuels make for a rich research agenda. The new dependencies and changing nature of the emerging energy game, and especially the co-existence of fossil fuel and renewable energy during the transition, ensure plentiful opportunities for further research on the novel field of the geopolitics of renewables.

First, now that the volume has provided the necessary groundwork in scoping the field and highlighting the main challenges to country's energy security, obvious next steps are more detailed investigations of the geopolitical or energy security implications of individual renewable energy technologies, renewable energy characteristics or related expectations, or concrete renewable energy projects, like the geopolitical ramifications of the North Sea offshore grid for all related countries.

Second, one can also investigate more specifically certain effects of renewables. Apart from the likely winners and losers, we may ask for example about future bottlenecks in supergrids, the risk of de-diversification due to electrification, or impacts on global energy and energy production technology trade volumes.

A more country (relations) oriented approach that centres policy challenges and responses, providing concrete strategies and instruments to handle new challenges would certainly be welcomed by policy makers. These could also be specified per stage of the transition and scenarios could be added for investigating no regret options. Alternatively, one could focus on international institutional solutions that mitigate potential strife, at least to the extent that military interventions become legal battles.

Fourth, we can also broaden the field to investigate how energy geopolitics influences the energy transition or whether other interpretations of geopolitics reach the same conclusions. In this light, the discussion of whether we should zoom in on renewables' characteristics or look at the implications of the broader energy transition would also be of interest to investigate.

Fifth, more conceptual contributions aimed at enriching established insights on energy geopolitics and energy security, perhaps even international relations and international political economy, with the experiences of renewables would also be very welcome. The developed framework could also be utilized to chart in more detail how the different characteristics of (renewable) energy systems affect geopolitics, in a theory-building effort.

To sum up, this volume established a comprehensive overview of the main geopolitical changes renewables bring and a basic understanding of the emerging energy game. It has put the novel topic of the geopolitics of renewables on the map, essentially scoping the field of investigation and providing the conceptual groundwork for further research. It is now time to take it to the next level.

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