

Chapter 1

Introduction: Dynamics of Energy, Environment, and Economy; A Sustainability Perspective



Hassan Qudrat-Ullah

Abstract A better understanding of energy-environment-economy interactions and a genuine appreciation and recognition of the alarming effects of climate change are the essential pre-requisites for any effective energy policymaking in a country. In this context, this book contributes with 13 unique chapters covering three major themes (i) dynamics of energy and economy, (ii) dynamics of energy and environment, and (iii) dynamics of energy policy and climate change. Methodologically, a range of theoretical, mathematical, econometric, empirical, simulation, optimization models and perspectives are used by authors to investigate various issues related to energy-environment-economy interactions. This chapter presents a systematic pre-view of the content of this book.

Keywords Energy policy · Energy-environment-economy interactions · Econometric models · Electricity supply and demand · Climate change · Environmental emissions · Sustainability · Decision making · Policymaking · Renewable energy · Electricity energy security

1 Introduction

Energy and environmental prosperity are imperative for sustainable development. At the same time, the economies of all countries, and particularly of the developed countries, are dependent on secure supplies of energy. On the other hand rising demand for energy especially with fossil-based supplies poses serious threats and dangers of environmental emissions. Climate change effects add to the complexity of energy policymakers. Unless renewables make a big impact on the supply side of energy, the noble goal of achieving sustainability and sustainable development will

H. Qudrat-Ullah (✉)
School of Administrative Studies, York University, Toronto, ON, Canada
e-mail: hassanq@yorku.ca

remain elusive. Therefore impetus this book is to address the vital and interwoven areas of energy, environment and economy in the crucial sustainability perspective. Figure 1.1 provides an integrated view of the critical interactions among key variables of the energy sector: energy policy influences the supply and usage of energy, the trajectory of sustainable development activities, and regulatory oversight for the environment. In return, the status of the environment (e.g., level of emissions), energy supply and demand gap, and nature of economic development activities provide critical input to energy policymaking. Likewise, energy policy, energy usage, sustainable economic development, and environment interactively affect each other.

This book provides comprehensive coverage of these crucial topics covering fundamental technical details, empirical data, case studies taking into account local and international perspectives. The critical sustainability challenges and emerging response and trends especially depleting fossil fuel reserves, global warming and climate change and international and global policies and protocols are covered. The book is written in a reader-friendly manner presenting vital details in the form of text boxes, tables and illustrations.

Unified by the common goal of making better decisions in the sustainable production and consumption of energy, we invited potential authors to submit and showcase their work related to the major theme of this book, “Dynamics of Energy, Environment and Economy”. In response to our call, after a double-blind review process, 13 contributions (chapters) authored by well-reputed scholars are presented in this book. Methodologically, a range of theoretical, mathematical, econometric, empirical, simulation, optimization models and perspectives are applied by the scholars in their chapters to investigate the issues relevant to the understanding of the dynamics of energy-environment- economy interactions.

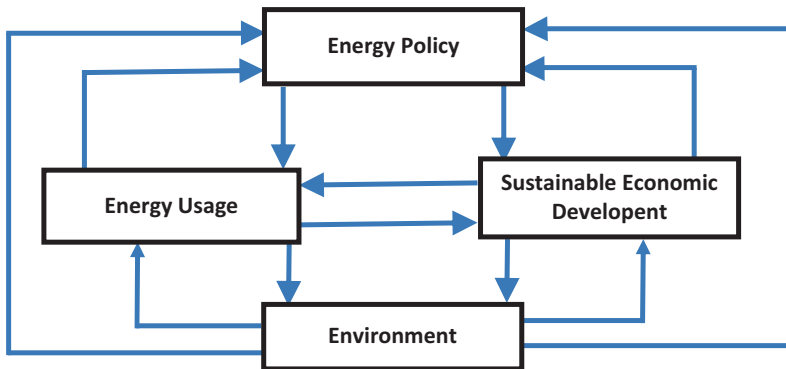


Fig. 1.1 A macro view of energy-environment-economy interactions

1.1 Methodology

In our call for contributions to this volume on “Dynamics of Energy, the Environment, and the Economy: A Sustainability Perspective,” we went through various email lists of professional associations IEA, IRENA, IPCC. We also posted the call for chapters at the message boards of a few international conferences on the related topics. Personal invitations were also sent to target authors as well. We received a total of 21 “two-page” long abstracts as the expression of interests. Based on the initial screening by our review panel, the authors of 16 chapters were invited to submit the complete chapters. We received 16 chapters from the contributors that went through a double-blind review process. The reports from the independent reviewers were sent to the authors to address the issues and incorporate the suggestions made by the reviewers. Only 13 chapters made it to the final stage of acceptance. The final versions of these 13 chapters have been edited and included in this volume.

1.2 Research Categories

The chapters thus compiled are classified into five categories following the structure of the book. The first category, the current one, presents the introduction and preview of “Dynamics of Energy, the Environment, and the Economy: A Sustainability Perspective” The second category examines the dynamics of energy and the economy. Four state-of-the-art chapters in this theme include (i) *The Framework of Renewable Energy Systems and Trends to Promote the Energy Security of the State of Baja California*, (ii) *Importance of Energy for Industries and Role of The Energy Sector in Turkey’s Economy*, (iii) *Impacts of Electricity Subsidies Policy on Energy Transition, and (iv) ZEMCH Strategic Framework for Low Carbon Solutions in Sustainable Housing Delivery*. The third category showcases four unique contributions addressing the challenges of energy-environment dynamics: (i) *Role of Hybrid Energy System in Reducing the Effects of Climate*, (ii) *Sustainable Solar Energy*, (iii) *Coupling Behavior-based Intervention with Pro-environmentalism? The Dynamics of Energy Usage, Crisis and its Conservation*, and (iv) *Dynamics of the Wind-power Supply Chain to Reduce Emissions: How it Affects Transmission Congestion?* The fourth category in this book highlights the role of institutions, energy policies, energy use-behavior, and increasing demand for a better understanding of climate change and energy policy dynamics in a sustainability context. In this category, we have five chapters (i) *Climate Change and Energy Policies: European Union-Scale Approach to a Global Problem* (ii) *The Role of Institutions in Energy Policy and Environmental Protection*, (iii) *Access and Limitations to Clean Energy Use in Nigeria*, (iv) *The Nexus of Climate Change and Increasing Demand for Energy: A Policy Deliberation from the Canadian Context*, (v) *Energy Policy and Climate Change*.

The final category, Finally, overviews the key insights and learning points as well as the future research avenues contained in this book.

2 Dynamics of Energy and the Economy

2.1 *A Framework of Energy Security Through Renewables*

Energy security and economic development go hand in hand. Lopez-Leyva et al. ([this volume](#)) in Chap. 2, “The Framework of Renewable Energy Systems and Trends to Promote the Energy Security of the State of Baja California” presents an analysis and conclusion regarding the role of energy security in the development of Mexico. According to them,

The concept of security is very important for the economic and social development of any region, state or country. In particular, the concept of energy security is now more important due to the negative effects of climate change and the high dependence on fossil fuels. Thus, the traditional energy security based on the use of fossil fuels is becoming highly questionable and renewable energies seem to be the best option to provide true energy security taking care of the environment and society in general. This chapter presents the current framework of renewable energy systems that impacts the energy performance and availability in the state of Baja California (which is part of the Cali-Baja region, formed by the hypothetical union of the states of California and Baja California) with the objective of promoting the energy security of the state. Finally, an analysis and conclusion regarding the energy security of the state are presented based on the energetic potentialities considering the autochthone renewable energy sources and the current energy regulatory framework of Mexico.

2.2 *Role of the Energy Sector in Turkey’s Economy*

Through a comprehensive analysis utilizing the input-output modeling, in Chap. 3, “Importance of Energy for Industries and Role of The Energy Sector in Turkey’s Economy”, Topcuoglu and Orla ([this volume](#)) examined the importance, impact, structure and relationship of the energy industry with other industries for the case of Turkey. They used the input-output model to analyses 2002 and 2012 data. They obtained input coefficients matrix, Leontief matrix and Leontief inverse matrix via the Input-Output tables of 2002 and 2012. They analyzed key sectors in the economy, forward and backward linkage effects and income, output and employment multipliers of all industries with the input-output model. According to the results of their analysis, the energy industry was found to be the key sector in both years and the energy industry has an important place in the Turkish economy. Their key findings are (i) although the output multiplier value in the energy sector is high, employment and income multiplier values are found to be low, (ii) the low value of the income multiplier in the energy industry shows that Turkey is dependent on foreign energy and (iii) the high production multiplier value in the energy industry means that the degree of structural correlation is high.

2.3 Dynamics of Electricity Subsidies Policy on Energy Transition

In Chap.4, “Impacts of Electricity Subsidies Policy on Energy Transition” Dhakouani et al. ([this volume](#)) present a critical review and analysis of the impact of electricity subsidies policy energy transition in the case of Tunis. According to the authors of this chapter,

Energy subsidy programs are socio-economically designed to offer modern and affordable energy, accessible for specific social groups, protect the domestic industry, stimulate economic development and protect the environment. However, in several countries, energy subsidies have deviated from their objectives and become an energy budget burden and a sustainable development barrier. Many questions arise: what are exactly energy subsidies? How are they implemented in a country mechanism? And what are their real effects?

In this chapter authors present a review of energy subsidies: definitions, typologies, measurement approaches and effects. They also examine the reforms to help decision-makers phase out energy transition barriers related to subsidies. They present the case of the Tunisian power system in deeper detail, characterized by a heavy burden of end-users electricity subsidies and an energy transition aiming 30% of renewable energies by 2030, against 3% in 2019. Using a holistic approach, based on hybrid energy systems modeling, they present insights on reforming electricity subsidies and achieving sustainable development. This approach, according to authors, links subsidies, pricing, emissions, demand and supply of the power system through the advanced version of OSeMOSYS. Finally, dynamics between energy, economics and environment are appealed within an integrated analysis of electricity subsidies policy.

2.4 Energy Efficiency as a Framework for Low Carbon Solutions

Low carbon solutions are at the heart of the UN’s Sustainable Development Goals. Noguchi ([this volume](#)) in this chapter, Chap. 5 “ZEMCH Strategic Framework for Low Carbon Solutions in Sustainable Housing Delivery”, presents a strategic framework for low carbon solutions in sustainable housing delivery. According to Noguchi,

In the light of Sustainable Development Goals acknowledged by the United Nations, homes today need to be socially, economically, environmentally and humanly sustainable. This diverse sustainable housing production challenge necessitates multidisciplinary stakeholders’ effective collaboration on the R&D actions. To form the global collaboration platform, the ZEMCH Network was established in 2010. ZEMCH is an acronym of Zero Energy Mass Custom Home which was conceptualized with the aim to function as a new domain for sustainable housing development in global contexts. For the purpose of ZEMCH design, production and marketing knowledge generation, collection and dissemination, the global network initiated and operated the academic conferences, industry-focused technical study

tours and the design training workshop. In consequence, several housebuilders and housing manufacturers, who participated in the knowledge transfer activities, embarked on ZEMCH delivery in their local contexts.

In this chapter Noguchi crystallized ZEMCH strategic framework for low carbon solutions in sustainable housing delivery through reviewing the design, production and marketing innovations applied to ZEMCH practices selected in Japan, Canada and Scotland.

3 Dynamics of Energy and Environment

3.1 On Dealing with the Effects of Climate Change Through Hybrid Energy Systems

Continuing with the theme of dealing with the effects of climate change, Bhattacharjee et al. ([this volume](#)) present in their chapter, “Role of Hybrid Energy System in Reducing the Effects of Climate,” simulation-based analysis of the role of hybrid energy systems in reducing the effects of climate change. According to them,

Climate change is a very rising topic nowadays since the climate of this world is changing rapidly day by day. In the technical field, it is seen that so many things or techniques used here, which have a very bad impact on our environment like the use of non-renewable energy sources, emission of greenhouse gases and so on. At present electric power generation is mainly dependent upon non-renewable sources. Due to the rapid uses of non-renewable energy sources, its storage reserves are decreasing rapidly. So an alternate source is required and that is the renewable energy source, nowadays renewable sources are utilized but in a small amount. Renewable sources are environmentally friendly, so using renewable energy sources are more preferable than non-renewable sources for the betterment of our environment. Due to rising environmental concerns day by day, the utilization of renewable energy need to be increased as much as possible. There are so many remote or island places in this world where huge numbers of renewable sources are available which can be used for power generation. And the most important thing is that they have no effect (or very less effect) in this environment. So our goal is to model and simulate a grid-connected solar-wind hybrid energy system which is used to solve the problems regarding power generation.

In this chapter, Chap. 6, the authors present a 24-h case study analysis by taking the real-time data of solar radiation and wind speed of a selected location. The results of this analysis indicate that the hybrid system is profitable and environmentally friendly. Their analysis includes a detailed discussion on climate change, the harmful effects of non-renewable energy sources on the environment and the need for a renewable energy-based hybrid energy system to combat climate change. They hop, by this explanation we will get to know more about how renewable energy sources mitigate two problems – climate change & power demand.

3.2 Solar Energy and Environmental Emissions Reductions

Advancing the theme on “renewable energy and environment”, George ([this volume](#)) in his chapter, Chap. 7 “Sustainable Solar Energy” delineates in detail the solar technology and its impact on dealing with environmental emissions. According to Geroge,

Solar energy is one of the most rapidly developing renewable energies in the world. The global solar PV market has been exceeding future market projections and giant untapped markets are only now waking up. For many years proposals have been made about using the Sahara desert as a place where a gigantic solar farm would be able to power the world. But is solar energy always the best solution out there? What can hold it back? What are some major drawbacks it has? Not all solar energy applications are created equal. Even amongst certain applications – for example PV- there are numerous technologies that are competing for greater efficiency, lower cost etc. In fact this can go even further, as apart from the more mainstream PV and solar thermal panels, other applications exist such as solar parabolic troughs, solar concentrators, solar desalination, solar ponds etc.

In this chapter Geroge provides an overview of various solar technologies, explains their characteristics and discusses case studies and scenarios for best practice in regards to maximizing energy yield, minimising environmental impacts and making sure that solar energy is used in the most sustainable way possible.

3.3 Energy Use Behavior as a Tool for Pro-environmentalism

Prabatha et al. ([this volume](#)) in their chapter, Chap. 8, “Coupling Behavior-based Intervention with Pro-environmentalism? The Dynamics of Energy Usage, Crisis and its Conservation,” provides a comprehensive review and analysis of the dynamics of energy use, crises, and its conservation. According to the authors of this chapter,

Higher cost and crisis of energy vis-à-vis increasing consumption have been a twin but a contested paradox. The rapidly growing energy demand has prompted many countries, including Canada to undertake manifold energy-saving initiatives. However, these are predominantly technology-driven and no apparent measures are taken yet to address and modify the end-users’ behavior in the residential sector. In order to reduce the rate of growth of residential energy consumption, it is critical to engage the end-users through better education and awareness while using the inherent pro-environmental behavior (PEB). This is even more critical e.g. for the new immigrants and first nation Canadians. Given this background, this chapter essentially presents (i) the importance of behavior-based, non-technical interventions on end-users’ perceptions of energy conservation; and (ii) its impact on the nature of consumption at the household level. Empirical findings from the East and current practices from the West are drawn to investigate these phenomena. The other part sheds light on the prospect and need for behavior-based interventions toward reduced energy consumption. While the time of use (TOU) is in effect, some forms of PEB exists among the residential users in Ontario. With this taken into account, the paper calls for a renewed policy insights on ‘investment’ and ‘curtailment’ behavior approaches to assess the ‘longevity’ effects on energy consumption. This, in turn, stems the foundational need for

'collaborative' think-tank for the multi-disciplinary professionals, including engineers, urban developers, environmentalists, planners, sociologists, economists, and psychologists.

3.4 On Dealing with Environmental Emissions Through Wind-power: A Case Study in Brazil

Promoting renewable wind-power as a mean to deal with the environmental emissions, Herra et al. ([this volume](#)) in this Chap. 9, "Dynamics of the wind-power supply chain to reduce emissions: How it affects transmission congestion?," present a case study in the context of Brazil. They posit that delays in new transmission line construction produce drawbacks that can lead to a precarious energy planning. According to them,

As there is a delay between the licensing process and complete lines, it could create uncertainty as well as transmission congestion. In this context, it is essential to estimate the impact the transmission congestion might have on the reduction of emissions. To assess the effects of power grid congestion on emissions; first, it was necessary to design a simulation model, then some simulation scenarios were provided for analyzing the dynamic behavior of the wind-power supply chain.

In this chapter, they present the findings of the case study conducted in Brazil. Their analysis shows that options to reduce emissions through the current energy policy of Brazil might be affected by delays in transmission construction.

4 Dynamics of Energy Policy and Climate Change

4.1 On Dealing with the Effects of Climate Change through Energy Policies

Adding to the theme of "energy policy and climate change," in Chap. 10, "Climate Change and Energy Policies: European Union-Scale Approach to a Global Problem", Sahin and Ayyldiz ([this volume](#)) present an econometric-based analysis of energy resources and climate change. The goal of their research was to examine the relationship between climate change and energy resources within the scope of the European Union by using static panel data method and Root Mean Square Error methodologies for the period of 1990–2018. Specifically, they evaluated the effects of the consumption in nonrenewable and ecological energy resources on CO₂ emissions. Under the related purpose, the variables of CO₂ emissions, which have the greatest impact on the climate change parameter among the greenhouse gases; oil, natural gas, coal, nuclear energy, hydroelectric energy, wind energy, geothermal energy, solar energy and biomass energy-related to energy parameter were used.

According to their findings of the unit effective fixed-effects model; it was concluded that coal, natural gas and oil consumption increased CO₂ emissions while ecological energy consumption decreased CO₂ emissions. Oil consumption was the most influential variable in CO₂ emissions. Root Mean Square Error findings indicate that the variable which has the highest effect on CO₂ emissions is geothermal energy consumption; and the lowest effect variable is the consumption of oil energy.

4.2 Energy Policy and Environmental Protection in Pakistan

Asif and Majid ([this volume](#)), authors of this Chap. 11, “The Role of Institutions in Energy Policy and Environmental Protection,” makes the case for the role of institutions in shaping the energy use and environmental awareness in a country. They begin with the assertions that the sustainable development of a country largely depends on its energy production and efficient utilization of available natural resources. In this regard, the role of institutions is very much imperative to set the rules of the game. In their chapter, authors discuss (i) the nature of institutions and types of social institutions, (ii) the theories related to the institutions, and (iii) the concept of energy and environmental constraints. They contribute with a case study on the environmental protection act and energy policy of Pakistan.

4.3 Access and Limitations to Clean Energy Use in Nigeria

Popoola and Adeleye, in Chap. 12 “Access and Limitations to Clean Energy use in Nigeria” contribute with a review and analysis of various factors and experiences of clean energy usage in Nigeria. They begin by asserting that the energy situation in Nigeria has always been a paradox. According to the authors,

despite having abundant energy resources in the country, widespread energy poverty is faced by the citizenry: about 60% (74 million) are not served with electricity, while another 94% (171 million) do not have access to clean energy. In a bid to cushion the effect of energy poverty, households and business enterprises in Nigerians relied on the constant use of generators, which is not eco-friendly, is costly and is harmful to human health.

In their study they adopted a think-through thematic methodological analysis, which involves the mapping of the country’s potential clean energy sources. Then the thematic literature reviews were integrated to investigate the clean energy experience in the country. Taking into consideration the geopolitical classification of the country, they conducted interviews to examine the energy conditions in the country and the limitation to the maximization of clean energy within their locality, as well as the perception of its acceptability within the country. Their findings show that the main factors limiting the use of clean energy in Nigeria are exorbitant costs of installation and maintenance, inadequate investment in the energy sector;

non- involvement of the private sector, and the subsidies granted to generators of energy from fossils.

4.4 The Nexus of Climate Change and Increasing Demand for Energy

Energy use and its impact on climate change is the subject of this chapter, Chap. 13 “The Nexus of Climate Change and Increasing Demand for Energy: A Policy Deliberation from the Canadian Context.” Karunathilake et al. ([this volume](#)) discuss this topic by conducting a comprehensive review. According to them,

Canadian energy demand has been increasing due to population, industrial, and economic growth, and the effects of climate change have gained more visibility. Energy use is a major contributor to anthropogenic climate change. Therefore, global scale energy management strategies are paramount in climate change mitigation. However, the complicated ‘marriage’ between climate change, energy demand and consumption, and the policy instruments too. Therefore, this paper attempts to study the effect of policy instruments on energy demand and identify other causes behind the demand trends. A comprehensive review of governmental policies assessed the consistency and effectiveness of existing policy instruments. Communication models for the participatory involvement of stakeholders in mitigation initiatives as well as the financial benefits and offsets were critically evaluated. Often, the views of some stakeholder groups, including the individual households and citizens are not successfully captured in policies. There is an apparent gap between the regulatory instruments and policies at the territorial, provincial and local governments. Most stakeholders possess limited knowledge due to missing or partial information about energy demand and the outcomes of various policies.

Authors hope that this paper will trigger scholarly discussion focusing on the dynamics of energy demand and regulatory instruments and policies for climate change mitigation.

4.5 Energy Policy and Climate Change

In the final contribution to the theme, “Energy Policy and Climate Change”. Dubey ([this volume](#)) presents in his Chap. 14 “Energy Policy and Climate Change” a comparative analysis of several countries’ energy policies and their relationship with climate change. Dubey begins his analysis by posing some serious questions. He says,

Is economic growth and development a zero-sum game vis-à-vis the environment; i.e. must economic welfare always come at the cost of environmental damage? This is one of the most fundamental questions facing humanity today – whether there is a way for both the economy and the environment to flourish, or if we must always make trade-offs between what’s best for each. Avoiding knee-jerk reactions wholly in favor of either side is important for society, as evidenced by the disorder experienced in several countries around the world at the hands of self-declared guardians of the environment. The fact is that climate change

is not limited to a national boundary but is tied to international actions and reactions. While the price an economy pays for a sustainable future is purely a local price, the social costs resulting from environmental damage is shared globally. Hence, even if a government completely capitulated to the environmental extremists' demands, there would still be environmental impacts to mitigate. In addition to developing energy policies to reduce carbon emissions, policymakers must act to ready their economies to deal with climate change. Can energy policies be designed to simultaneously provide social and environmental benefits? The answer is an emphatic yes.

In this chapter then he shares examples of a select subset of countries, reviewing their climate change agendas and targets, in conjunction with supporting environmental policies. Specifically, he provides a systematic assessment of the economic impacts of such measures, and the long-term impacts of such policies on energy supply and demand.

In the final chapter of this book, Chap. 15, Asif ([this volume](#)), conclude with key insights gleaned from the showcased contributions in this book. Both the researchers and the practitioner can get a quick glimpse of this book by ready this finally.

5 Concluding Remarks

For this book project, we started our journey in search of “theoretical and empirical underpinnings of the dynamics of energy, environment, and economy within the context of sustainability perspective”. In this quest, we are successful in presenting 13 unique contributions in three major themes: (i) dynamics of energy and economy, (ii) dynamics of energy and environment, and (iii) dynamics of energy policy and climate change. With regards to the theme of “dynamics of energy and economy” we have four leading contributions addressing the key issues pertaining to energy security, renewable energy supply, low carbon economy, and sustainable economic development. Also four chapters from renowned scholars of the field support the theme “dynamics of energy and environment”. Finally, the “energy policy and climate change” theme have five equally unique contributions covering the critical aspects of dealing with the effects of climate change. These critical aspects include the effective design of energy policies, enactment of regulatory measures, and the initiation of clean energy initiatives. Consistent with the objective of this volume “*in the context of a global perspective*,” we have six state-of-the-art contributions from Brazil, Mexico, the US, Canada, the Middle East, Pakistan, Australia, and Europe.

It is worth noting that contributions in this volume have deployed a range of theoretical, mathematical, econometric, empirical, simulation, optimization perspectives and models to investigate the critical issues relevant to the integrative nature of sustainability through a better understanding of energy, environment, economy interactions. Also, by utilizing the identified research gaps summarized in the final chapter of this book, researchers in the energy systems domain can

continue their research on important issues related to climate change and energy-environment-economy dynamics.

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