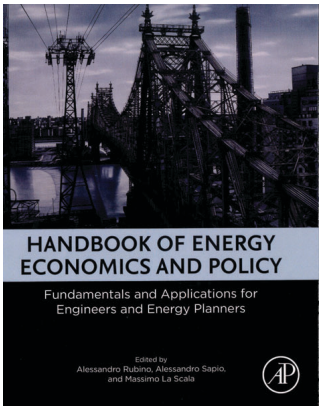

Handbook of Energy Economics and Policy: Fundamentals and Applications for Engineers and Energy Planners. Alessandro Rubino, Alessandro Sapio and Massimo La Scala (eds). Academic Press, an imprint of Elsevier, 125 London Wall, London EC2Y 5AS, United Kingdom. 2021. xviii + 674 pages. Price: US$ 200. ISBN: 978-0-12-814712-2.

With the growing population and technological advancement, there is an ever-increasing need for energy in various forms across the globe. Energy is no more a luxury; rather, it is a fundamental need. Given the growing demand and limited supply of energy with associated challenges, it is vital to examine the economic and policy aspects of energy, including its supply and demand implications. Against this backdrop, the book under review presents a collective work of 30 energy experts based on their theoretical knowledge and practical experiences from various parts of the world. It also presents a good mix of historical multi-country evidence, qualitative research and quantitative analyses. It will be useful to postgraduate students, policymakers and energy professionals.

The book contains 16 chapters classified into three parts. The first part 'Fundamentals of energy industry' has seven chapters highlighting the elements of structures, drivers and the market of energy systems. It also discusses carbon market and carbon risk management. The second part on 'Economics and policy of energy transition' with six chapters, constitutes the soul of the book. It highlights energy innovation, sustainability, energy transition and storage technologies. Furthermore, from a regulatory and socio-economic perspective, this part also covers energy system planning, geopolitical implications and the role of public funding and collaboration in renewable energy. The third and final part, the 'Energy data modeling and forecasting', which is primarily targeted at academic and applied researchers, is quant-heavy. It discusses econometric and machine learning models as well as complex systems applied to energy systems and electric mobility planning.

The first chapter presents the fundamentals for understanding the energy sources and energy carriers. Fossil fuels (coal, oil, and natural gas) and renewable natural resources (solar, wind, geothermal and hydropower, etc.) are the main sources of energy, while electricity is the main carrier of energy to cater to the energy demand. Historically, coal has been the dominating fuel source for energy generation and is expected to remain so in the future. This is due to its vast availability, affordability, and cheap technology to handle it. However, we do not consume the energy directly; the benefits derived from the energy, including heating, cooling and transportation are our final consumption. With growing population and thereby consumption of energy, there has been a significant increase in energy demand as well as carbon dioxide (CO_2) emissions. One of the solutions to issues pertaining to growing energy demand and CO_2 emissions is increase in energy efficiency. The chapter recognizes the technological advancement, transition to renewables, information and communication technologies (ICTs), and policy initiatives responsible for energy efficiency enhancement and climate change mitigation. The challenges associated with these alternatives are discussed elaborately in the later chapters.

The second chapter analyses the structure of energy demand. The energy demand is seasonal and dynamic in nature. Depending on individual lifestyle and energy consumption style, the energy demand pattern varies. It is important to study this dynamic pattern of energy demand to balance the supply–demand mismatch. The chapter highlights that energy demand is elastic in nature and hence demand-side management is helpful to control the peaks in demand. In support of this, case studies pertaining to the demand-side management are presented from several European countries. The time-dynamic energy tariff and smart metering are some of the solutions proposed in this chapter for demand-side management.

The counterpart of demand is 'supply', which is discussed in the third chapter. It starts with a discussion on the basic economic theory of energy supply. The supply curve is typically influenced by the price in the energy market. Energy price is dependent on three factors: value of resource, technological advancement and Government regulations. A high-value resource, if extracted and handled with advanced technologies and backed by Government subsidies, may cost less and hence could be affordable. However, the transportation cost structure and supply chain widely differ with the type of fuel (oil, gas and electricity). The chapter also highlights the finance structure for energy supply, which is highly capital-intensive. Three common sources of financing for energy projects are discussed: (i) the investor's own funds (applicable in developed economies); (ii) banks or institutional investors (applicable for short-term financing), and (iii) capital markets (applicable for long-term financing). In addition, indirect participation of the Government through tax incentives in energy supply is also recognized. Along with energy supply, energy security is also vital, especially for emerging economies. Energy security refers to an uninterrupted supply of clean energy at an affordable cost. To support the ideas stated regarding energy supply and security, this chapter ends with a case study of an independent gas producer in Russia, who introduced an optimal, resilient and efficient mechanism for gas supply.

Extending the discussion to energy supply, chapters 4 and 5 deal with the specific issues of transportation of gas and electricity. However, the book does not include a discussion specific to the transportation of another major energy source – oil. Historically, gas was considered a by-product of hydrocarbon extraction. Later, the US pioneered the establishment of a gas market. Due to its low storage density and high permeability, gas transportation is both technologically and economically challenging. Its operation is broadly categorized into upstream (from well to gas hub), midstream (gas hub) and downstream (gas hub to consumers) phases. Similarly, electricity transportation has two broad phases: transmission (generator to transformer) and distribution (transformer to consumer). These phases encounter operational and geographical challenges which have cost implications. Both gas and electricity transportation are highly capital-intensive and therefore result in monopoly. However, to protect the consumers' interests, monopoly must be either broken or regulated by the Government. This is achieved through open market operations, price regulation, negotiation and long-term contracts.

Chapter 6 highlights the wholesale market and regulations in electricity and gas that cater to a major part of global energy demand. Through case studies, the chapter summarizes the following factors which contribute to the changes in the energy market and its structure: (i) ever-growing energy demand, (ii) emergence and involvement of new technologies, (iii) active participation of customers through demand–response (discussed in chapter 2), (iv) balance between economy and ecology, and (v) capture and storage of carbon emission caused by energy transmission and consumption. Carbon emission and climate change are the negative externalities of the energy market and must be addressed for a sustainable economic growth. In this direction, chapter 7 elaborates on the issues pertaining to the 'carbon market'. Carbon trading was started by the European Union in 2005, but it has still not acquired momentum due to the developmental goals of many developing as well as developed countries. Clean Development Mechanism and the Kyoto Protocol are important initiatives to manage the carbon market and mitigate climate change.

To address the impact of climate change while meeting the increasing energy demand, energy innovation and sustainability transition are required, as discussed in chapter 8. Although carbon emission per unit of energy consumption has been reduced due to energy innovation and renewables, more innovation and transition are required to further reduce carbon emission and make the energy market sustainable. To achieve this, a multipronged approach involving active participation of technology, economy, society and policy is required. Historically, an increasing number of patents suggests growth in energy innovations. Since innovation – generally a disruptive event – has its own technological, economic, societal and political limitations, renewable energy is the best alternative to cater to the ever-increasing energy demand while reducing carbon footprints. Chapter 9 discusses the impact of renewable energy sources on the energy system, with a special focus on solar and wind sources which have a success story among renewables. Both wind and solar energy share common characteristics that are different from conventional energy sources. These are: (i) near-zero carbon emission in operation; (ii) near-zero operational cost; (iii) uncertain power generation and (iv) asynchronous interconnection to the power system. While the first two characteristics are favourable to the sustainable energy system, the latter two pose a challenge. Uncertainty in generation can be addressed by developing the storage system (battery) and the demand–response mechanism. Improvements in the transmission system like 'smart' inverters and coordinated distributed resources can address the issue of asynchronous connectivity.

The regulatory implications of energy storage systems are covered in detail in chapter 10. Energy storage is essential primarily for two reasons: (i) trading of energy at different times, and (ii) avoidance of transportation, and complex transmission and distribution networks. Together they bring more flexibility to the energy system. Although storage of energy does not guarantee a reliable future energy system, it can be mutually beneficial to both producers and consumers in terms of flexibility and efficiency in operation. The chapter enumerates the following regulatory challenges in integrating energy storage into the mainstream energy system: (i) altering the market design and (ii) restructuring the tariff structure. The chapter ends with prominent case studies of two energy leaders, i.e. Germany and California, USA, which have successfully designed and implemented policies for energy storage to respond to energy demand both efficiently and flexibly.

An alternative for responding quickly and flexibly to the growing energy demand and urgent need of fast-growing economies is the 'multicarrier' energy system, as discussed in chapter 11. Multicarrier refers to the synergistic combination of multiple energy carriers: electricity, gas and heat energy. Electricity can be transported, but not stored easily. In contrast, heat and gas can be stored, but not transported easily. Integration of these energy carriers increases flexibility and reliability of the supply and helps in capacity optimization. The chapter ends with the demonstration of a mathematical model for optimization of a multicarrier supply system.

Chapters 12 and 13 respectively, highlight financial and geopolitical issues pertaining to renewable energy. Due to lack of maturity, high investment volumes and high-risk factors, innovations in renewable energy technologies fail to attract large and early investors. In the renewable energy segment, only solar and wind technologies have been relatively successful in obtaining finance from Government and private investors across the globe. Typically, the Governments support initial funding for R&D, and later, as the renewable energy technologies attain maturity, private players take over the financing. If this transition in financing is not smooth, the renewable technology suffers from a 'technology valley of death'. Geopolitical challenges for renewable energy are also bottlenecks for renewable technology growth. To address these issues, interventions by the Government as well as collaboration with private partners are equally important.

Chapter 14 describes the macro-evolutionary approach to model the complex interaction between producers and consumers in the energy market. This approach helps in finding the optimal energy mix and responding to the fluctuating demand. It focuses on the diffusion of innovation and ways to support the process with appropriate policies. On the basis of a sound literature review on the macro-evolutionary approach, this chapter explains Jevons' 'rebound effect' (1865) and Jensen and Skytte's 'merit order effect' (2002). The rebound effect refers to the increase in energy consumption due to increase in energy efficiency. The merit order effect refers to the use of renewables to reduce the overall energy cost.

The last two chapters present econometric modelling techniques for electricity price forecasting and complex system applications to electric mobility respectively. These chapters are primarily intended for readers with an engineering background and an understanding of stochastic processes. The chapters are highly mathematical. With stylized facts about the electricity market, chapter 15 presents the time-series forecasting technique for electricity prices by incorporating the trend and seasonality. The limitations of such forecasting models are as follows: (i) useful only for long-term and low-frequency forecasts (quarter or annual), but not for short-term and high-frequency forecasts (hourly or daily); (ii) lack of data; (iii) economic interpretations of the complex models, and (iv) replication of incumbent models with updated data. Given these limitations, the chapter suggests using output from multiple models instead of relying on a single model. In the case of high interaction between multiple factors of the energy system, the use of a complex system is suggested in chapter 16. A complex system is defined as one that has (i) complex interactions and nonlinear dependency between the elements; (ii) dynamic and unpredictable elements, and (iii) delicate elements sensitive to the macroeconomic changes. Such uncertain and dynamic

elements with complex interactions in the energy system have been dealt with in the previous chapters. They include carbon market, renewable integration, regulatory constraints, multicarrier energy system, energy storage, energy financing and geopolitical challenges. In the presence of many such new, dynamic and uncertain elements in the energy system, complex models are useful. They help solve problems pertaining to the demand forecast, supply–demand balancing and meeting the energy demand efficiently with a minimum carbon footprint.

In summary, the book presents a homogeneous mix of economic and policy perspectives on energy systems. To strengthen the arguments, the authors have referenced an adequate amount of empirical literature, wherever appropriate. Tables and figures are judiciously used to depict historical findings and facts. The hypotheses are validated with an elaborate narration of relevant case studies that provide the right context. Finally, algorithms and mathematical models are presented to lay the foundation to implement the theories for further research and analyses. Overall, this is an excellent contribution to the field of energy policy research.

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