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# Introduction

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Preparing an introductory chapter for a book in which the academic and professional level of the contributing authors is so high is not an easy task. A quick definition of the *Handbook of Sustainable Energy* could be something like: ‘an attempt to contribute significantly to the knowledge in sustainability issues from the point of view of energy’. This book is an interesting effort to shed some light on such a complex topic as energy use and sustainability.

Part I starts by recognizing the importance of the use of energy in all past and present civilizations and socio-economic systems. In fact, the most reasonable way to forecast correctly and to drive the future use of energy in a sustainable way is possibly by looking far back to the past. This is done in Chapter 1 by Fouquet, focusing on the use of renewable energy sources and the lessons that can be learnt by looking at very long-term periods. Chapter 2 sets the scene for detailed discussion regarding what sustainability means in the field of energy systems, being aware that intergenerational and international (or interregional) justice are fundamental conceptual dimensions of the definition of sustainable use of energy resources and technologies. Hammond and Jones include very interesting concepts in the analysis, such as resource productivity (the so-called ‘factor X’), the precautionary principle and the three dimensions of sustainability – economic, environmental and energy – illustrating the discussion with examples from the field of biofuels and decentralized energy resources. The historic responsibility of developed countries is stressed and magnificently clarified.

But the fact is that the use of energy is at the very core of one of the greatest challenges facing humankind: climate change and its impacts. And moreover, energy use is a fundamental part of the solutions necessary to mitigate climate change. Understanding the complexities attached to the public nature of this problem, the fact that today’s efforts will generate benefits in the future and the discussion on how to delink economic growth from green house gas (GHG) emissions are the central pillars of Chapter 3 by Gallastegui, Ansuategi, Escapa and Abdullah. The authors shed some light on the questions: (1) Can economic growth be delinked from GHG emissions? (2) Can GHG emissions be cut without hurting economic growth? And (3) Is future economic growth at risk due to climate change?

Another key component for sustainable use of energy is availability, that is, the security of supply. Bigano, Ortiz, Markandya, Menichetti and Pierfederici offer in Chapter 4 a view of how energy security policies are connected to energy efficiency and saving. They show that reducing energy consumption reduces dependency on external energy sources, and thus it should be a central part of any energy security policy. Econometric analysis is used to study the effect of efficiency and saving indicators in security of supply indicators for the EU-15 and Norway. They conclude that many energy efficiency policies in the European Union (EU) are not effective by themselves, and the right policy mix is the best approach to achieve energy security goals successfully.

Guaranteeing the supply of energy to maintain quality of life and continue with productive activities can be managed in many different ways, but the truth is that any smart policy has to recognize the significant role that innovation has to play in this field. Climate policies need to be supported by research while designing effective carbon-pricing mechanisms; changes in energy use and the role of civil society in the promotion of a transition to a low carbon economy cannot be neglected. Planning efforts in the UK and the Netherlands are used to explain clearly what is necessary for a transition to a low carbon economy in Chapter 5 by Foxon.

Part II on energy and economics starts with Chapter 6 by Bonacina, Creti and Dorigoni. They explain how gas and electricity markets work, while describing the role that economic models have played in market design and transmission regulation. An interesting portrayal of the way in which the EU has restructured its gas and electricity markets is offered, stressing the fact that Europe still needs to define a clear common energy policy to move towards competitive, integrated and green energy markets. Chapter 7 by Pérez-Arriaga, Gómez, Olmos and Rivier analyses the role of electricity as well as the changes required to move towards a low carbon economy. They conclude that without adequate transmission and distribution networks the path towards a sustainable low carbon energy model will not be possible. The following two chapters analyse different approaches to modelling energy and economic interactions. Rodrigues, Gómez-Plana and González-Eguino, in Chapter 8, offer the reader a review of the energy–economy–environment (3E) models and the fusion of the bottom-up and top-down approaches in the so-called hybrid models. Although there exist a number of restrictions to the use of these models, they are very useful tools for informing energy and climate policy decisions. Chapter 9 by Pittel and Rübhelke illustrates how endogenous growth models allow us to understand the long-run potential of economies to overcome the scarcity of fossil energy resources, and the potential and direction of technological development. The authors differentiate between analytical solvable endogenous growth models and computable general equilibrium (CGE) models, and the role of research and development (R&D) investments. Finally, Madlener and Harmsen-van Hout analyse consumer behaviour towards energy use in Chapter 10. They study different drivers that explain human behaviour: (1) psychological drivers (cognition); (2) rational behaviour drivers (utility); (3) sociological drivers (other people); (4) ecological drivers (environment); and (5) technological drivers (innovation). The analysis enables them to identify commonalities and differences that are otherwise easily overlooked.

Parts III and IV are devoted to analysing different technology options for sustainable use of energy and transition to a low carbon economy. Chapter 11, by Yoshizawa, Stirling and Suzuki, outlines a general framework for analysing energy diversity and synergies for transitions to sustainability. It provides a multicriteria diversity analysis method as a more systematic, complete and transparent way to articulate energy portfolios. Chapters 12 and 13 are devoted to renewable energy. Cabal, Labriet and Lechón conduct a deep literature review gathering the most recent data from the most relevant studies on global and European potentials for wind power, hydropower, biomass, solar power and ocean energy. At global level, photovoltaic and thermosolar power account for 80 per cent and 90 per cent, respectively, of the total renewable power potential. At a European level, however, wind power is the technology with the biggest potential. Once the potential is estimated (with a wide range of measures) Halsnæs and Karlsson analyse

the penetration of renewable energy depending on the cost of individual options and on how a portfolio of options can be integrated in energy systems in a way that energy access, energy security and climate change policy goals are met. Chapter 13 illustrates how this has been played out in international scenario studies, and in a particular study for Denmark where the goal is to cover all Danish energy consumption by renewable energy in 2050. They conclude that having 100 per cent renewable energy in Denmark is not very costly given the favourable local conditions for high penetration of wind energy and large-scale electricity trade with Scandinavian countries and Germany.

Another main theme of the book relates to how to bring about energy and carbon efficiency as a central to the goal of a sustainable energy future. The book covers the two main sources contributing to CO<sub>2</sub> emissions – the power sector and the transport sector – and where efficiency and saving measures can be relevant. Abadie and Chamorro in Chapter 14 look at incentives to invest in enhancing energy conversion efficiency in power plants that operate under carbon constraints. Many investments to enhance energy conversion efficiency at coal plants are not undertaken, due to difficulties in determining future earning in energy savings and CO<sub>2</sub> emission rights. They provide some interesting results applying real option analysis. The numbers are used to provide several policy recommendations based on the idea that there is a clear role for public authorities in promoting investments in innovation and R&D in coal-based plants. Chapter 15, by Button, looks at ways of improving efficiency in the transport sector. The author proposes moving from broad perspectives (such as the ‘sustainable transport’ notion) to a firmer theoretical foundation that leads to policy development and implementation.

Part IV comprises three chapters devoted to nuclear energy, carbon capture and storage (CCS) technology and biofuels. Hammond in Chapter 16 deals with the rather controversial topic of nuclear energy. This is a CO<sub>2</sub> zero-emitting energy source that has great opposition worldwide. This chapter offers a technical and well-developed position on the topic. The author argues that the need to develop more secure and commercially viable nuclear plants will indeed be determined by the attitudes of the public sector towards this energy source. Anthony and Fennell in Chapter 17 outline the various CCS technologies that might be deployed in the next few decades to meet the requirements of a carbon-constrained world. In particular, they show that the focus has been on technologies which could reasonably be expected to be commercially available in the next ten to 20 years. According to the authors, correctly applied CCS technology will buy time for a transition to systems with increased energy efficiency, and large-scale use of renewable and nuclear power. Finally in Part IV, Chapter 18 deals with the ‘promises’ and ‘risks’ of bioenergy. After a careful analysis of all the issues, Hazell and Evans recommend that countries should be encouraged to slow down on their biofuels mandates, allowing time to reduce the existing trade-offs with food provision and to protect remaining primary forest and peatlands from conversion to agriculture.

Part V deals with energy and climate policies. Chevallier offers two very interesting chapters, on CO<sub>2</sub> and energy pricing, and the flexible mechanisms of the Kyoto Protocol – the EU Emissions Trading Scheme (EU ETS), the Clean Development Mechanism (CDM) and the Joint Implementation (JI). In Chapter 19 a retrospective view of the EU ETS for the 2005–07 period shows the weaknesses and strengths of this market so far. In Chapter 20 the author explains the connexion between the ETS and the CDM/JI through the Certified Emission Reductions (CERs) of project-based instruments and

the EU Emission Allowances of the EU ETS. Labandeira and Linares offer a broader perspective in Chapter 21, to tackle the complexities of first-best policy solutions in climate change issues. The authors describe a number of reasons that justify a second-best approach to climate policy. Carbon tax itself may not be the best instrument to deal with climate policy and, therefore, a combination of instruments will be necessary to address the multiple market failures and other second-best situations that arise in the real world. In Chapter 22, Westskog, Winther and Strumse deal with policies to reduce energy consumption, following a wide multidisciplinary approach by including concepts from anthropology, psychology and economics to understand behaviour in order to be successful in driving changes. They show that technology itself will not address energy saving targets, and thus behavioural aspects are essential, as changes in energy consumption are closely linked with choices and sociocultural factors that determine the choice of policy instruments to be used. Finally, to close Part V the role of R&D is deeply analysed in Chapter 23 by Lanza and Verdolini. They go through the future prospects for all the main energy technologies and relate them with patent data. They conclude that the wide energy portfolio needed to face the challenge of climate change will require significant investments in the innovation, adoption, diffusion and transfer of technologies. The role of both public and private partners is acknowledged.

Part VI, the last of this book, opens with an important issue: the impact of the transition to a low carbon future in poor countries. Chapter 24, by Bailis, looks at energy poverty in a global context and at the reforms needed to eliminate it, while also respecting the goals of improving energy and carbon efficiency. The author argues that distributional issues are critically important and that in the absence of policies to promote inclusive access to energy services and associated technologies, additional supply may simply reinforce poverty and inequality across scales.

The last theme explored in the book is the role of regions in helping to move towards a sustainable energy future. Regional governments (defined as a subnational level of governance) have an interesting advantage over national governments: the fact that they can be more innovative and can act as 'leaders' in the formation of public opinion in this field. The book offers three good examples: North Rhine-Westphalia (Germany), California (USA) and the Basque Country (Spain). Chapter 25 by Reisz focuses on the case of the North Rhine-Westphalia region, analysing the effect of a decentralization process of energy production, where electricity in future will be produced in the place where it is going to be used, offering greater scope for the regions to influence the energy markets. Chapter 26 by Heres and Lin analyses the case of California, a very interesting example of a US state with a climate policy that is much more ambitious than the federal one. Nature offers California the possibility to develop renewable energy sources, while the political will is providing the opportunity to achieve it. Chapter 27 by Hormaeche, Galarraga and Sáenz de Ormijana looks at the case of the Basque Autonomous Community to illustrate the potential of regional governments to develop their own energy policies in the broader context of the EU. According to the authors, while the expectation is that European and national regulation offer a fairly restricted playground for regional governments, the truth is that there exists plenty of room for manoeuvre for this level of governance. This represents a great opportunity that should be explored and that can surely contribute to improving energy and climate policy worldwide.

The Epilogue by Markandya offers some of the highlights and key trends in this rich

collection of contributions, suggesting that this book will be of great interest for many readers and offer a lot to researchers in the field.

We cannot finish this introduction without expressing the deepest thanks of the three editors to each and every one of the contributing authors for their intense effort and excellence in presenting their analysis. We hope that you, the reader, will find it interesting and learn as much as we, the editors, have done during the journey of the preparation of this book. Enjoy it!

