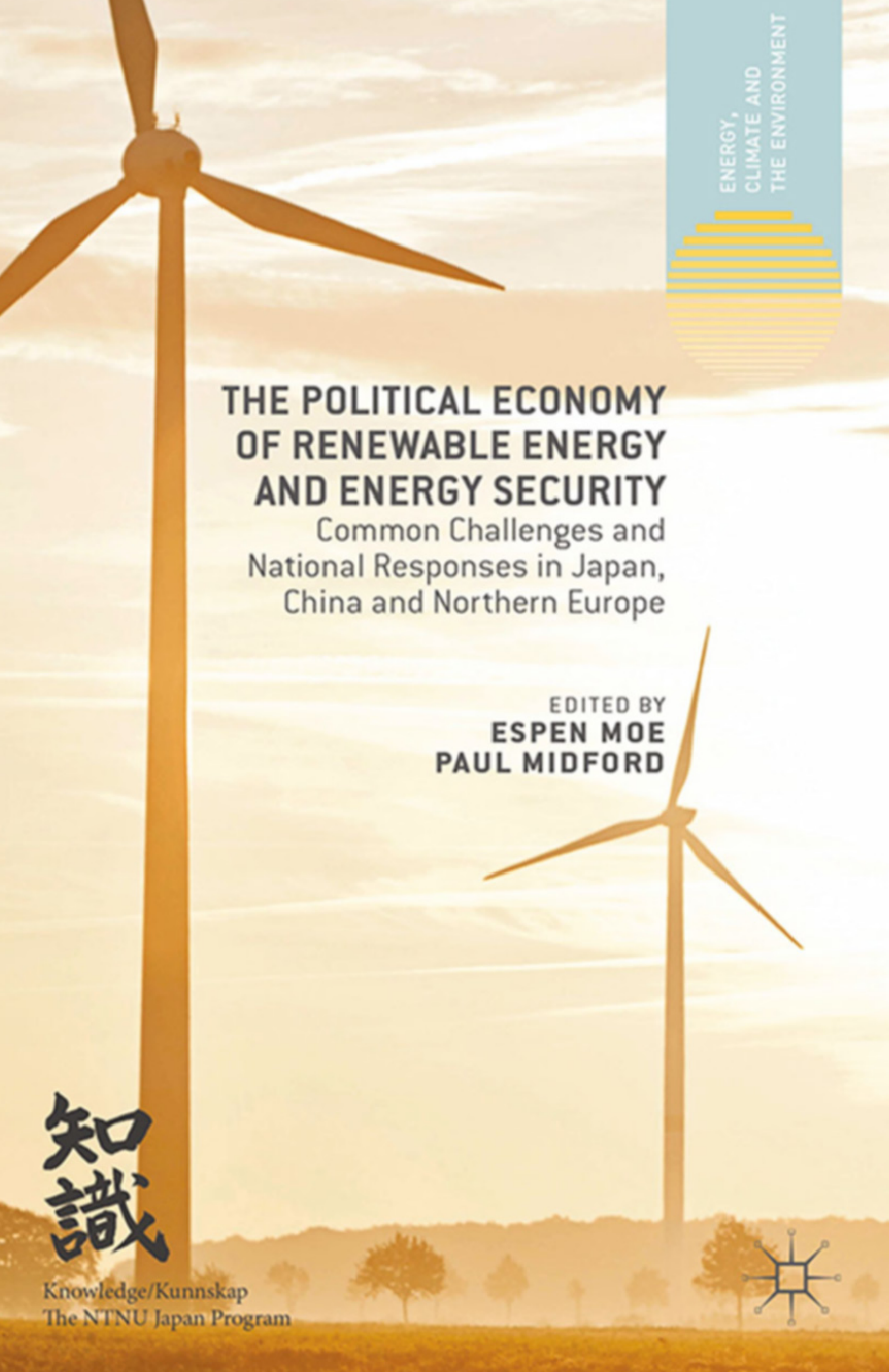

ENERGY, CLIMATE AND THE ENVIRONMENT

THE POLITICAL ECONOMY OF RENEWABLE ENERGY AND ENERGY SECURITY

Common Challenges and National Responses in Japan, China and Northern Europe

EDITED BY
ESPEN MOE
PAUL MIDFORD

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The Political Economy of Renewable Energy and Energy Security

Common Challenges and National Responses in Japan, China and Northern Europe

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We dedicate this book to our parents.

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Series Editor's Preface

Concerns about the potential environmental, social and economic impacts of climate change have led to a major international debate over what could and should be done to reduce emissions of greenhouse gases. There is still a scientific debate over the likely *scale* of climate change, and over the complex interactions between human activities and climate systems, but global average temperatures have risen, and the cause is almost certainly the observed build-up of atmospheric greenhouse gases.

Whatever we now do, there will have to be a lot of social and economic adaptation to climate change – preparing for increased flooding and other climate-related problems. However, the more fundamental response is to try to reduce or avoid the human activities that are causing climate change. That means, primarily, trying to reduce or eliminate emission of greenhouse gasses from the combustion of fossil fuels. Given that around 80 percent of the energy used in the world at present comes from these sources, this will be a major technological, economic and political undertaking. It will involve reducing demand for energy (via lifestyle choice changes – and policies enabling such choices to be made), producing and using whatever energy we still need more efficiently (getting more from less), and supplying the reduced amount of energy from non-fossil sources (basically switching over to renewables and/or nuclear power).

Each of these options opens up a range of social, economic and environmental issues. Industrial society and modern consumer cultures have been based on the ever-expanding use of fossil fuels, so the changes required will inevitably be challenging. Perhaps equally inevitable are disagreements and conflicts over the merits and demerits of the various options and in relation to strategies and policies for pursuing them. These conflicts and associated debates sometimes concern technical issues, but there are usually also underlying political and ideological commitments and agendas which shape, or at least colour, the ostensibly technical debates. In particular, technical assertions at times can be used to buttress specific policy frameworks in ways which subsequently prove to be flawed.

The aim of this series is to provide texts which lay out the technical, environmental and political issues relating to the various proposed policies for responding to climate change. The focus is not primarily on the science of climate change, or on the technological detail, although there will be accounts of the state of the art in order to aid assessment of the viability of the various options. However, the main focus is the policy conflicts over which strategy to pursue. The series adopts a critical approach and attempts to identify flaws in emerging policies, propositions and assertions. In particular, it seeks to illuminate counter-intuitive assessments, conclusions and new perspectives. The aim is not simply to map the debates, but to explore their structure, their underlying assumptions and their limitations. Texts are incisive and authoritative sources of critical analysis and commentary, indicating clearly the divergent views that have emerged and also identifying the shortcomings of those views.

The present text is no exception in exploring new trends and challenging received wisdom. It seeks to show, through a series of national case studies, how energy issues increasingly open up new interactions between policy areas which were previously sometimes seen as separate or of low priority – for example energy security and climate policy are now often dominant in economic policy concerns. The selection of countries for study includes major players like China, Germany and Japan, who are all in the process of accelerating the expansion of renewables, alongside smaller players like Denmark and Norway, the former being a pioneer in wind power and the latter increasingly being seen as the 'green battery of Europe', given its large hydro capacity. The Norwegian material emphasizes the importance of grid development and grid balancing, as renewables expand: the technological emphasis is moving from specific supply issues to system-level issues. However, that is set in a wider context of debate about sustainable energy support policy – how to promote the development and deployment renewables successfully. And, on that, the case study chapters and analysis in this text provide many lessons and pointers.

David Elliott

Preface and Acknowledgements

This is the first Norwegian University for Science and Technology (NTNU) Japan Program Policy Study. It is hoped that this study, and the others that follow, will contribute to understanding the major policy issues that face Japan and their relevance for other advanced industrial democracies and, indeed, for the global community as a whole. Japan faces a number of policy challenges in common with other advanced industrial democracies, especially those in Europe. The focus is on using common values as the basis for overcoming common challenges. Energy insecurity and renewable energy constitute one such policy area, and is the subject of this first NTNU Japan Program Policy Study. The next study will look at common challenges facing Japan and Norway in care for the elderly.

The NTNU Japan Program originated in the 1980s and early 1990s, when a number of NTNU scientists and engineers conducted research at Japanese universities as visiting scholars. Based on very favorable experiences and interest from Norwegian industry, NTNU established its Japan Program in 1998. Since the program's establishment it has offered courses on Japanese language, society and politics, and also on East Asian politics. Another hallmark of the program is its annual Japan Seminar, which has become a leading venue for presenting and promoting the latest research on Japan and East Asia in Northern Europe and beyond. It also is a cross-disciplinary seminar and especially promotes cross-disciplinary cooperation between engineering and natural sciences on the one hand and the social sciences on the other.

The present volume emerged from two NTNU Japan Seminars on energy security and renewable energy, the first held in 2008, the second held in 2011, and a panel on energy security held at our 2012 seminar that focused on Japan's recovery from the 3–11 earthquake, tsunami and Fukushima nuclear accident. It is from the 2011 seminar that the idea for this volume emerged. The central idea underpinning this book, and one of the main missions of the NTNU Japan Program itself, is to bring together insights from engineering and the natural sciences on the nature of technological change together with social science insights on how technology affects society, and how society in turn affects the development of technology, its diffusion and use.

Renewable energy and energy security illustrate both the opportunities and the necessity for promoting this collaboration. For social scientists it seems to go without saying that we depend on engineers and natural scientists to get a clear and accurate picture of the current state and changing nature of technology, a picture that is an absolute prerequisite for us to understand how technology and technological change affects society, economics and politics. Our success in understanding all these fields is thus increasingly tied to understanding technological change. On the other hand, the funding, success and diffusion of innovative technology are not always simply a function of the degree of innovation and the capabilities of the technology in question. Often, the success of new technology follows a social logic more than a technological logic. Among other factors, human perceptions of risk and benefit, economic and political interests can either promote or inhibit the success of any technology, regardless of technological merit.

The area of energy security and renewable energy offers rich examples of this. The inter-play of perceptions of risk and benefit, and economic and political interests, have exercised a powerful impact on which types of energy technology are adopted and diffused, and which are not. The interplay of these social factors plus the objective strengths and weaknesses of various technologies is a theme vividly illustrated in the chapters of this book.

We can see this interplay in the debate about energy security, in the debate about the comparative merits of various forms of renewable energy, such as wind and solar, and also in the debate about the merits of nuclear power – debates that are now raging in Japan as never before. It is striking how often these debates boil down to assertions about comparative technical feasibility: Is it easier to secure nuclear power plants against any kind of earthquake or tsunami, or to build more efficient solar cells or deal with the inevitable power flux/intermittent nature of solar and wind energy? Indeed, in an era of rapid technological change it is not hard to imagine that given a long-enough time horizon, all these goals could be largely achieved, which means that these debates are perhaps not ultimately about technological feasibility, even though that is how they are often portrayed.

Rather, the technical issues in these debates often mask the real issues at stake, which are more about values, interests, identity, and perceptions of risk that in significant respects are independent of science and technology. Thus, these debates will ultimately have to address values, interests, identity, and perceptions more directly in order to come to a successful conclusion. What forms of energy will best represent our values, material interests, identity, and risk tolerance? In short, half of the answer to this question will be technological, and the other half will be social. We believe this volume makes an important contribution to addressing both sides of this question, the technical and social aspects of renewable energy and energy security.

We owe thanks to a great many people who contributed directly or indirectly to this volume. In particular, we would like to thank participants from the two NTNU Japan Program seminars from 2008 and 2011 from which this volume emerged, and another panel on energy policy held at the 2012

Japan Seminar, including: Taro Kono, a member of the lower house of the Japanese Diet, and the keynote speaker at the 2011 seminar; Finn Gunnar Nielsen of Statoil; Ryuji Shimada and Takanori Isobe of the Tokyo Institute of Technology; Ivar Wangensteen and Robert Nilssen of the Department of Electric Power Engineering at NTNU; Natsuyo Ishibashi, who was a post-doctoral researcher in the NTNU Japan Program from 2010 to 2012; and Eivind Lande, a PhD candidate in the Japan Program. We would also like to thank Paul Scalise, JSPS Research Fellow at the University of Tokyo, and a leading renewable energy skeptic, for being an excellent debate partner as Midford tested out new ideas that proved highly relevant for his chapter and this volume.

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Contributors

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Research is a major European Research institute on techno-economic issues related to energy and climate, and Ruud has been responsible for extending this research into non-technical, social-scientific concerns. As part of his new position, Ruud has also been responsible for social scientific research at the Centre on Environmental Design of Renewable Energy (CEDREN) in Norway, in which he is member of the management group. Ruud is member of the editorial board of the journal *Business Strategy and the Environment*.

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1

Introduction

Espen Moe

Introduction

Energy issues are at the forefront of the political discourse as never before. In a world of $100-per-barrel oil, potential peak oil, and with climate change looming ever larger on the horizon, there is an obvious need for a fresh and critical look at energy politics. The idea of this book, stemming from a conference on renewables and energy security in Japan, East Asia and Norway, hosted by the Japan Program at the Norwegian University of Science and Technology in 2011, has been to blend not only perspectives on renewable energy and energy security, but also those of the natural and the social sciences. Building on the conference, this book has developed into a volume on renewables and energy security in Japan, China and Northern Europe. It offers a distinctive blend of theories, methodologies and geographical cases. One of its cornerstones is the notion that energy security and renewable energy, while often treated as distinct in the general literature, are inextricably linked. Blending perspectives of the natural and the social sciences has also been important. Too long has the field of energy been dominated by a discourse of technical problem-solving. But few areas are now more political. Energy is becoming a strategic resource to an extent that we have not seen since the 1970s oil crises. There is growing concern that energy is not just another tradable commodity in a smoothly functioning and apolitical and global liberal market economy, but that in the future its abundance and ubiquity cannot be taken for granted. Once the 1970s oil crises were forgotten, the energy security debate of the 1980s and 1990s shifted away from risk diversification and oil as a strategic asset towards simply buying petroleum in the market as cheaply as possible. In the words of Japan Research Institute president, Jitsuro Terashima, (2012): For Japan, 'securing energy supply meant building bigger oil tankers'. But the days of blind trust in global oil markets may be coming to an end. Energy will to a greater extent become subject to strategic thinking among energy-importing and energy-exporting countries, bringing energy security back to amongst the foremost issues of the political agenda (see also Chapter 2 of this book, by Gunnar Fermann). The political nature of these issues – issues that are both of high technical complexity and of major importance to the world economy – means that only by bringing in the linkages between the technological, the economic and the political, can we make a meaningful contribution to the field.

Renewable energy also has a very clear political component to it. We obviously need to take into account the technological innovations and limitations that make energy technologies and industries such a crucial part of economic growth and of everyday life. But we also need to focus on the political processes and the political economy of energy production, as in the pursuit of policies of renewable expansion and in the implementation of these policies.

Energy and energy policy are interesting for the number of linkages they have to other areas. Energy is an area where cross-disciplinary efforts are at their most useful. Energy is linked to foreign policy and to geopolitics through, among other things, energy security. And the links to the political economy are obvious as energy prices most certainly affect the world economy. Energy use is at the core of modern-day economic growth processes. Throughout history there has been a symbiosis between industry and energy. Without new sources of energy, new growth industries would have been improbable. Also, the relationship between energy and political institutions is extremely important. Energy companies are among the world's biggest industrial giants.[1] They wield enormous political influence, and have often managed to secure institutional arrangements that further their own interests. Thus, in many countries, there is a strong bias in favor of the present energy structure, based on fossil fuels (sometimes nuclear) and on big, centralized energy utilities. Finally, energy policy has obvious linkages to industrial policy and climate policy. There are certainly countries that have tried to combine breakthroughs in energy technologies with the promotion of export industries (for instance, both Japan and China). And the argument that the expansion of renewables is necessary to meet climate commitments is one that is made routinely.

By studying a number of quite different countries, we can compare and contrast very different experiences and policies. This makes it easier to draw lessons from the empirical material, lessons that might otherwise remain hidden. Japan is small and densely populated, with few natural resources of its own to satisfy its energy requirements, but is wealthy after 150 years of industrialization. China is a potential superpower, with the largest population in the world, abundant in a number of natural resources, but scarce in others, still poor, but with growth rates so impressive and persistent that satisfying its future energy needs will present major challenges, both to China and the global energy system. Northern Europe is represented by Germany, Sweden, Denmark and Norway, with illustrative empirical material from other countries. Norway provides most of the subject matter. While obviously not an economic powerhouse like Japan or China, from an energy point of view Norway is a highly interesting country. Small and scarcely populated, it has benefited from being well-endowed in petroleum, and before then in hydropower. Some even see Norway, with its very large hydro reservoir capacity as becoming the storage battery of Northern Europe, helping Denmark, Germany and others to balance the variability of their renewables (Gullberg, 2013). But this also means that, despite a national identity in which closeness to nature and environmental consciousness are important components, Norwegian efforts in renewables beyond hydropower have been feeble. Thus, Norway serves as a counterpoint to Japan and China, and is an outlier in the Northern European context as well, showing what a major challenge it will be to implement strong renewable policies in a country dominated by petroleum. The other Northern European countries bring their own specific contributions, demonstrating the complexity and rich variety of the region's renewable and energy security policies. Germany is an economic powerhouse of global stature. It has for long been a frontrunner on renewables, and its feed-in tariffs (FITs) are widely emulated. Also, following Fukushima, it has turned away from nuclear power, something that presents major challenges in terms of energy security, but also a major challenge – and an opportunity – for renewables in terms of plugging the gap in electricity production that will inevitably follow, making for an obvious comparison with Japan (see otherwise Frank Umbach, Chapter 3). Denmark may be a small country, but it was *the* frontrunner on wind power, and remains a leader, not just being the country with the highest density of wind turbines in the world, but also hosting the wind power giant Vestas. Finally, smart politics is becoming ever more important, making Sweden – one of the frontrunners on Smartgrids – a highly interesting country.

For this book, we have brought together a broad team of scholars from Northern Europe, Japan and China. While they obviously offer different perspectives, approaches and methodologies, their chapters are united by the common perception that renewable energy and energy security should have, at its core, a focus on the intersection among the technological, the economic, and the political. It is only by bringing out the linkages among the three that we can gain a broader understanding of the political economy that underpins the challenges the world is currently facing on renewables and on energy security. Thus, running throughout this book is the argument that none of the three can be left out, which does however happen far too often. North et al. (2009) stress that every explanation of large-scale change contains a theory of economics, a theory of politics and a theory of social behavior, but that very often theories of economics and politics remain independent, scholars not coming to grips with how economic and political development are connected. Technical problem-solving may be an excellent vantage point for analyzing energy policy. But it only gets us so far. Thus, we have sought to link perspectives on economic and political development, together with the obvious technological bent that any study on energy tends towards, for a thorough understanding of the political economy of renewable energy and energy security.

The book is divided into three parts. The first focuses mainly on energy security. The Fermann chapter (Chapter 2) offers a broad theoretical perspective on energy security, introducing key concepts and theories, whereas Øystein Tunsjø (Chapter 5) and Jakub Godzimirski (Chapter 6) look into the energy security context of China and Norway, respectively. In Chapter 3 Frank Umbach looks at Japanese energy security since Fukushima and the recent German *Energiewende* (energy transformation), suggesting that Japan may learn from Germany's experiences with its nuclear phase-out. The Japanese policy debate has been active and intense. Paul Midford's chapter (Chapter 4) on Japanese public opinion and energy security demonstrates how public opinion is playing a crucial role in shaping energy and energy-security policy, and that public opinion has been far more important than it is often given credit for.

The book's second part has technological perspectives at its core, relating technological problems and drivers to the industrial, climate and energy problems that the technologies are meant to solve. Tore Undeland and Bogi Bech Jensen write about trends in wind turbine generator systems (Chapter 7), whereas Kenji Asano (Chapter 8) brings out the technologies and politics of solar photovoltaic (PV) as he discusses the rise and fall (and potential rise again) of Japan's PV sector. Often overlooked is the electricity grid. The grid is often a very concrete and very major obstacle to the expansion of renewables. Audun Ruud (Chapter 9) looks both at the technologies behind Smartgrids and at why a technology focus alone will not lead to success.

The final part has as its focus a social scientific analysis of the political processes pushing – or hampering – the development of renewables. Yu Wang (Chapter 10) looks at the impact of the original and the modified Renewable Energy Law in China. Jørgen Delman and Ole Odgaard (Chapter 11) analyze the 12th Five-Year Plan and assess the extent to which changes to the Chinese growth model can be expected in the future. Similar themes, of industry and growth interwoven with climate policy can be found in the chapter by Guo et al. (Chapter 12), with an explicit focus on how China is seeking to put itself on a low-carbon path. Karolina Jankowska (Chapter 13) analyzes German PV policies and how Germany became the world leader in PV, but also how the German system has come under threat, both from Chinese imports and from its own success, as government subsidies are becoming ever more expensive. Finally, in identifying institutional and industrial bottlenecks preventing the rise of renewables, Espen Moe (Chapter 14) looks at the vested interest structures of Japan, China, Norway and Denmark, the influence that vested interests wield over energy policy-making, and the extent to which vested interests have become entrenched in the institutional structures of these countries. Among the lessons is the ease with which renewable energy policy is co-opted by vested interests, and the crucial role of the state in pursuing renewable energy expansion.

Energy Access

Thematically, the chapters deal with a number of recurring topics. Energy access is one. Irrespective of whether or not we have reached peak oil, the world no longer has abundant access to inexpensive energy. Granted, Daniel Yergin (2011) holds forth that the world is still awash in oil. The world's proved oil reserves have kept on increasing, and if we take unconventional sources into account, there is no immediate peak oil. Instead, the question has become one of how eagerly do we pursue the remaining resources and open up new areas for exploration, and the extent to which new technologies can make resources that in the past were technologically unfeasible to exploit. Michael Klare (2012), on the other hand, forcefully states that while it is technically true that we are still awash in oil, the days of 'easy oil' are long gone. Over the next 25 years, the 'easy oil' fields will lose 75 percent of their productive capacity. Shale gas, breakthroughs in fracking, deep-sea drilling, and Arctic oil may prolong the petroleum age. But if the future is still fueled by petroleum, every pretense of this being a cheap and abundant source of energy must be abandoned. And knowing that at least since the Industrial Revolution, the link between energy and economic growth has been intimate, and that waves of economic growth have been fueled by the rapid exploitation of a new cheap and abundant source of energy (Ayres and Warr, 2009; Moe, 2010), a prolonged period of scarce and expensive energy could seriously jeopardize the growth prospects of the entire world economy.

Ideally, the petroleum age ought to end, not because we run out of petroleum, but because we discover new sources of energy. However, to Klare (2008; 2012) a more likely outcome is that the share of renewables will change only little by 2030, because overall energy demand will also keep increasing. Instead, we might be facing a race for the world's final remaining petroleum resources, and a future that we should all dread, both for its increased levels of conflict and for the impact that climate change will have on a world that refuses to move on to sustainable sources of energy.

Energy security and the case for renewables

What the above points to are two things, both of which are at the core of this book. First, that we live in a time when energy security is crucial and different countries have to deal with this issue in different ways, based on needs and on access to resources. Second, that alternatives to fossil fuels need to be phased in, for energy (security) and for climate reasons.

Renewables are obviously not the sole answer. Not to the energy problem, not to the climate problem, and not to future energy security problems. The future is open-ended and, undoubtedly, we will see technological progress and industrial opportunities in areas still unforeseen. However, sitting back and waiting for such progress to magically appear seems foolhardy at best. What we do know is that the future will bring major energy challenges, and at present there are no simple solutions to cheaply and conveniently resolve these problems. What we also know is that climate change will push us towards abandoning fossil fuels, or we face the consequences of a dramatically warming planet. And while recent climate summits have been disappointing, one would hope that as countries perceive of climate problems with more urgency, conditions for renewables will become ever more favorable.

Thus, while we cannot say that renewables will be the definitive industrial champions of tomorrow, the notion that renewables belong to a cluster of technologies and industries that will continue to experience rapid growth, seems a conservative one. True, the countries in this book have varied considerably as to the extent to which they have pursued renewables as an energy (security) strategy or as an export strategy. China, for instance, is by far the market leader in solar PV, supplying nearly 60 percent of global demand, but up until recently there was almost no domestic market. Thus, for China, solar was about exports only and not energy. However, in general, growth in renewables has been rapid. Between 1997 and 2011, wind-power capacity increased by more than 20 percent every year (dipping slightly below 20 in 2012). PV increased by 60 percent a year between 2004 and 2009, and annual investments in renewables have risen from $40 billion in 2004 to $279 billion in 2011. For several of the past few years the United States and Europe have added more power capacity from renewables than from conventional sources (EWEA, 2013; REN21, 2013; WWEA, 2013). As renewables become more price-competitive, and with a number of countries providing favorable economic and regulatory frameworks, renewable energy and industries should have a prosperous future. This is another reason why a book such as this, with renewables as one of its two main pillars makes sense.

However, success is not a given. Success crucially depends on framework conditions. Thus, this book contains several chapters (Asano, Chapter 8; Wang, Chapter 10; Guo et al., Chapter 12; Jankowska, Chapter 13; Moe, Chapter 14) that analyze the importance of framework conditions, the effort of the state, as well as identifying bottlenecks that hinder the rise of renewables in the political–economic system. But often forgotten is that renewables also require an infrastructure, and this infrastructure is often both costly and inadequately developed. Without a proper grid network, a country can expand its installed capacity to infinite levels without much impact on the overall energy situation. Wind turbines in particular are often installed in far-away locations, where wind resources are plentiful, but where the grid network is typically at its weakest. Thus, linking the installed wind power capacity to the electric grid is a serious problem, for example in both Japan and China. And while in many ways the expansion of renewables can be accomplished fairly easily – given the right support mechanisms – developing the grid takes time, money and deliberate government effort. One chapter deals explicitly with this (see Ruud, Chapter 9).

Barriers to change

The reluctance of some states to pursue renewable avenues of energy production on a large scale also has to do with the inherent power and influence residing in domestic institutional and industrial structures. In any society, there are a number of vested interests seeking to preserve the status quo, including the energy status quo (for example Moe, 2007; 2010). Unruh (2000) has labeled these structures techno-institutional complexes (TICs) – large technological systems embedded trough feedback loops between technological infrastructure and institutions. Once a structure is locked in, it is not easily dislodged. Institutions typically support the already existing actors in the political–economic system, and new and upcoming industrial actors have a far harder time getting access to political decision-makers. The current carbon-based TIC may easily be the most powerful yet, perpetuating a fossil-fuel-based infrastructure and exacerbated by government subsidies and institutions. For all practical purposes, this means that industrial change does not take place simply because new and promising technologies are available, or the price is right. It typically takes political action beyond mere market mechanisms to displace a TIC and implement a new energy structure. And so, structural energy change does not necessarily just happen by itself.

Major external shocks can sometimes be triggers for structural change. The 1970s saw two oil crises. They led Japan to stop taking energy security for granted. These crises rekindled awareness that Japan is among the least energy-secure countries on the planet, and that relying on oil imports at much increased prices might seriously hamper economic growth. This led to initiatives to find alternatives to fossil fuels, including a strongly funded program on solar power (even if the expansion of nuclear was the main strategy). This was an energy security strategy, but with new exports as a potential eventual spin-off. While Japanese solar power has had ups and downs, and while technological progress has been slower than what was anticipated in the 1970s, much progress has come from governmental initiatives as a response to the oil crises.

In March 2011 Japan suffered another external shock. Tragic as Fukushima was, it has ignited a vigorous national debate on energy security and the first serious Japanese rethink of energy policy since the 1970s. Several chapters testify to decades of stalemate and gridlock in Japanese energy policy-making. The influence of the electric utilities and the nuclear lobby on energy policy-making has been massive, much to the detriment of renewables. With Fukushima and the closing down of, at times, all of the country's nuclear reactors, Japan has lost roughly 30 percent of its electricity supply. This is a challenge from both an energy and an energy security perspective. Japan imports all of its oil. More than 80 percent comes from the Middle East, actually up from 78 percent in 1973. In this regard Japan has not done much to alleviate its vulnerability in terms of energy security (Terashima, 2012). Also, the immediate consequence of Fukushima has been that Japan increased its liquid natural gas (LNG) imports by more than a quarter. Japan is now both the biggest importer of LNGs and the third largest net importer of oil in the world. Thus, while Fukushima has led to a serious energy rethink, it has also made the energy security situation even more precarious, which might lead to an increase in coal consumption by nearly 20 percent before the end of this decade (Adams, 2012). But Fukushima could also be a window of opportunity. It has provided renewables with a boost, and it has challenged the power and influence of the most important vested energy interests of the country, that of the electric utilities and the nuclear village. It is still too early to make firm predictions – apart from the fact that nuclear power, which pre-Fukushima was scheduled for escalation,[2] may now be headed for a gradual phase-out. But no matter what happens, Fukushima may have been instrumental in breaking the deadlock of Japanese energy policy-making (see also Umbach, Chapter 3; Midford, Chapter 4; and Moe, Chapter 14).

China has not suffered any similar energy shock, but one of the realizations that have had an impact on Chinese energy policies is that climate change will hit China harder than most. Thus, China needs to bridge energy security concerns (see Tunsjø, Chapter 5) – Chinese demand for oil is currently rising by 3.6 percent a year (IEA, 2007) and since 2009 China has even become a net importer of coal (Delman and Odgaard, Chapter 11) – with energy-emissions concerns. The fact that wind power was singled out as one of the industries that should secure Chinese economic growth through the current global economic crisis says something about the seriousness with which China pursues renewables. At the same time, because of the overall increase in energy demand, we have seen little in terms of structural change in Chinese energy supply. The importance of coal in the overall energy mix is scheduled to come down somewhat (from 70 to 62 percent of total primary energy supply) but, in terms of absolute figures, China will keep increasing its coal consumption at rates that dwarf the rest of the world, increasing its amount of coal-fired plants by one third only in the next five-year period alone (Wang, Chapter 10; Delman and Odgaard, Chapter 11; Guo et al., Chapter 12). Put together, the China chapters contextualize the tension between the need for more energy and for security of supply and the realization that China needs to change its energy mix.

Barriers to change in major petroleum exporters work somewhat differently. The Norwegian case is quite different in the sense that here, sky-rocketing energy prices fill up the country's coffers rather than draining them. Energy security in a Norwegian context is thus more a matter of security of *demand* and of global market trends than security of supply, something which Fermann conceptualizes in Chapter 2 and Godzimirski treats more specifically in Chapter 6. The Norwegian discourse on energy security has hardly been a discourse at all. Instead, Norwegian energy policy has been framed in terms of technical problem-solving. It is about ways in which to extract as efficiently as possibly as much as possible from the Norwegian shelf, as well as about how much of the petroleum fortune should be saved for future generations. This has meant that the discourse on renewables has persistently had to play second-fiddle to that of petroleum. Furthermore, because of the abundance of hydropower, there has been no need to think strategically about other types of renewables. The 1970s oil crises coincided with Norway discovering oil in the North Sea, and at a time when the country had already expanded its hydroelectric resources to very impressive levels. Thus, the oil shocks had less of a policy impact than on other countries. In terms of the energy discourse, off-shore wind power represents a partial exception. It represents an opportunity in terms of industrial development and in terms of future exports, as well as energy production – Norway is an energy nation, and the North Sea hosts not only vast (but dwindling) petroleum resources, but also enormous potential for the large-scale expansion of wind power – and it represents an opportunity in terms of providing sustainable energy and in living up to Norwegian climate commitments. But only to a very limited extent have renewables been seen as the way forward for Norway in terms of energy supply and Greenhouse gas (GHG) emissions. Not so Denmark, where the 1970s oil crises triggered a completely different response. With nuclear power a political taboo, Denmark had to choose between greater energy imports and finding alternative means of energy production. Thus, Denmark has become one of the world's foremost producers of wind power, deriving as much as 27 percent of its electricity consumption from wind (EWEA, 2013). The German *Energiewende* is also a result of a shock, the German government up until Fukushima being intent on prolonging the life span of its nuclear power plants. Instead, nuclear will be phased out by 2022, and the share of renewables in electricity consumption will double from a current 17 percent to 35 percent by 2020. These goals are so ambitious (maybe even bordering on the unrealistic) that fulfilling them will entail major changes to German energy policy (Cleantechnica, 2012).

The future?

Predictions about the future can be notoriously imprecise, and hindsight is as always 20/20. The dawn of the oil age, now something that we take for granted, was for instance not something that could easily have been predicted. In the 1860s, gasoline was primarily a waste product. Instead, kerosene for oil lamps – a considerable improvement over sperm whale oil – was the driver behind oil drilling. This might easily have remained the case. In the 1870s in the United States, kerosene at one point was cheaper than drinking water, and the fourth-largest U.S. export in terms of value. Compared to gas, kerosene often did the job at a tenth of the cost. The threat instead came from electricity and the invention of the electric light bulb.[3] By the early 1880s, electricity – successfully lobbied for by, amongst others, Thomas Edison – was making kerosene look decidedly old-fashioned, and already in 1882 the bottom had fallen out of the kerosene market. This was deeply threatening to the young oil industry which, over the past few decades, had invested massively in production, refineries, pipelines, storage facilities and distribution. Thus was fueled the need to find a use for gasoline, which up until then had been of little use. And so, the fledgling car industry (Germans Daimler and Benz both manufactured their first automobile in 1886) became the new outlet for the oil industry. In 1900, gasoline-fueled cars accounted for only 22 percent of U.S. auto sales, but only a decade later it was the automotive fuel of choice, and in 1910 gasoline sales surpassed kerosene. In 1911, Winston Churchill, as First Lord of the Admiralty, did his to stimulate the rise of oil, when he decided that British warships should be converted from coal to oil, so as to be faster and more maneuverable than German ships (Mowery and Rosenberg, 1998; Shah, 2004; Yergin, 1990). In World War I, in the words of future British foreign secretary, Lord Curzon, the allies 'floated to victory upon a wave of oil' (cited in Yergin, 2011, p. 230). The world never looked back.

The advent of the oil age would not have been straightforward to predict and, paradoxically, to some extent it depended on breakthroughs within a different energy industry, that of electricity, and the consequent wiping out of what had up until then been the mainstay of the early oil industry, namely kerosene for lighting.[4] While this is not to say that a use for gasoline would never otherwise have been found, it should make us appreciate the extent to which the future is open-ended. Thus, in predicting the rise of renewables, we should not overestimate our predictive powers. And there is obviously also the possibility that a renewable revolution will be stillborn because of breakthroughs in as of yet unforeseen technologies.

Peak oil has been predicted before. From the 2011 consumption rate of 87 million barrels per day (mb/d), oil consumption will increase to 100 million mb/d by 2035 (IEA, 2012). The International Energy Agency (IEA) (2007) holds that world oil resources are sufficient to meet projected demand until 2030, but by 2050 conventional oil will yield hardly more than 92 mb/d. The rest will have to be provided by heavy oil, tar sands, shale oil, Arctic oil and biofuels. Simultaneously, as demand keeps increasing, oil reserves will exhaust at accelerating rates. At the moment we consume two to three barrels per newly discovered barrel (Energimyndigheten, 2006;

Tsoskounoglou et al., 2008). In short, for the first time in human history we are starting to bump up against the physical limits of the planet. And while this presents daunting prospects, both from an energy and a climate perspective, it should imply a bright future for renewable energy.

Yet, in many ways, these are both testing and turbulent times for renewables, their prospects more uncertain than only a few years ago. While, in the past, nuclear power was the obvious candidate to succeed fossil fuels, today the advent of shale gas and tight oil is threatening to be a game-changer. The IEA (2012) confidently predicts that by 2020, the United States will be the world's largest petroleum producer, overtaking Saudi Arabia and becoming a net exporter, and the U.S. Energy Information Administration is forecasting future oil output figures far more optimistic than those of the IEA.[5] Shale beds now account for more than 25 percent of U.S. natural gas and have made it possible for many to believe in a future in which petroleum is once again cheap and abundant, pushing prices down and volumes up. U.S. natural gas prices dropped from $12 per million Btu in 2009 to less than $2 in 2012. President Barack Obama (backed by Yergin) in January 2012 proclaimed that the U.S. has a supply of natural gas that will last nearly 100 years, and that his government will do what it can to exploit this energy (*Economist*, 2012b; 2013a; Heinberg, 2013, p. 53). China is closely watching, as its reserves may potentially be even twice as large as in the United States (Hu and Xu, 2013; Klare, 2013). As a potential game-changer, this could be seriously bad news for renewables.

That is, if the hype can be believed. There are major differences of opinion as to how much of the shale resources are recoverable, and production at the wells typically drops off by an astonishing 60–90 percent during the *first year of production*. Thus, in order to keep producing shale gas at current levels, ever more drilling at ever higher costs will be required.[6] And while Yergin is undoubtedly an authoritative source, others have estimated that U.S. shale plays will yield the United States less than ten years of extra natural gas (Heinberg, 2013; *LMD*, 2013). Also, while hardly unbiased, considering how their companies stand to lose greatly from a shale revolution, it is nonetheless worth noting how clearly Gazprom CEO Alexey Miller and Lukoil president Vagit Alekperov express the idea that shale is a bubble, hyped by Wall Street, and that this is something that the United States may justify from an energy security point of view, but not for economic reasons (*Voice of Russia*, 2013). If this is closer to the truth, then the oil lobby is doing the United States a serious disservice by urging energy policy away from alternative sources and back towards fossil fuels.

Nuclear power is another X-factor. The nuclear revolution never played itself out to the full. Nuclear has never provided more than 5 percent of the world's total energy supply (McNeill, 2001), and it dwindled seriously in popularity after Chernobyl. And as the world was starting to feel safe for nuclear once again, Fukushima happened. Fukushima led to Germany giving up on nuclear overnight and to Japan losing its entire nuclear power capacity. But, as Frank Umbach mentions in his chapter, the absence of nuclear, and the only gradual expansion of renewables, for all practical purposes makes it impossible for Japan to fulfill its Kyoto commitments, as the energy gap is made up for by massive LNG imports. In the meantime, other countries are increasing their nuclear power capacities. At the time of writing, 62 new reactors are being built worldwide, most of these in China, which is adding 26 reactors to the 16 that it already has. Thus, both for energy and climate reasons, nuclear may still have life left in it. Indeed, Fukushima has actually shown us how much more difficult combating global warming will be if it were to coincide with a nuclear phase-out. Still, even the major Chinese expansion will hardly bring the share of nuclear in Chinese electrical power generation to above 10 percent by 2030 (Andrews-Speed, 2012, p. 50; *TU*, 2012).

Another reason why these are testing times, is that the above developments have coincided with the most serious financial crisis since 1929. Green growth was advocated strongly by a number of countries, the idea being that the expansion of renewable energy should foster prosperous new companies and fuel economic growth, combining industrial policy and energy policy, while contributing favorably to climate policy. But renewables have not been the answer to the current economic crisis. In the past, major crises have often turned out to be moments of structural change. But in times of crisis, government subsidies for non-competitive industries become harder to defend. Thus, while Schumpeter (1983) teaches us that crises are times of creative destruction, they could also easily become periods of prolonged stagnation, with governments sticking with and supporting old and trusted industrial actors. In Europe in particular, countries seem to be holding on to what they have, rather than pursuing structural change. Thus, the crisis has meant a scaling-down of renewable efforts in several countries. After years of steady expansion, investments in renewables in 2012 dropped from $279 to $244 billion – mostly because of Europe (see Figure 1.1).

First, barring a few exceptions, renewables are still more expensive than fossil fuels, as well as often requiring a back-up load of energy (often coal) because of the intermittency of the energy flow, and adding to the costs. Marques and Fuinhas (2012) suggest that while phasing in renewables is important, this is not for economic reasons. In Europe, investments in renewables, because of increased electricity prices and expensive subsidies, have lowered growth rather than the opposite.[7] While it may constitute future avenues of growth, we are not yet there. Efforts have been costly, and occasionally unpopular – wind turbines are anything but invisible.

Second, renewables are expensive because they have been successful. Generous feed-in tariffs (FITs) have led to rapid expansion of both solar PV and wind. Consequently, government subsidies for renewables keep

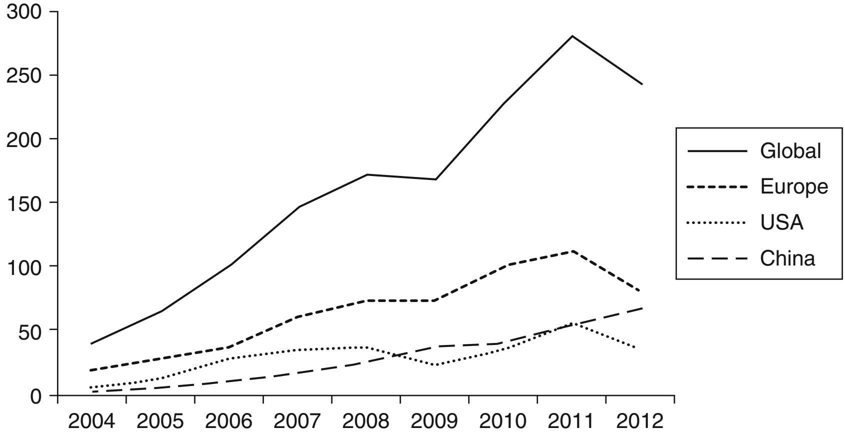

Figure 1.1 Global new investment in renewable energy, 2004–12 ($ billion)
Source: REN21 (2013).

increasing. Germany in 2012 paid more than €16 billion in subsidies for renewable power production, up from €4 billion as recently as 2007. Thus, as renewables become successful enough to account for more than a negligible part of electricity production, they also become expensive enough to challenge existing support frameworks. And so, a mostly European problem has been boom-and-bust cycles wreaking havoc, especially with PV. Generous FITs have led to major new PV installations, which have then become so expensive that FITs have been scaled back or abandoned. PV projects have then become unprofitable and PV manufacturers gone bankrupt. Also, generous FITs have to a large extent subsidized Chinese imports instead of fuelling domestic green growth. PV prices have dropped by up to 75 percent over the past few years. This sounds like good news. But this is mostly because of Chinese over-supply rather than technological progress, with Chinese manufacturers crowding out manufacturers in Europe and the United States. This is partially because the technologies are fairly familiar, and Chinese labor costs lower than in the West. But both the EU and the United States have also charged China with dumping, the United States slapping major punitive tariffs on Chinese PV.[8] PV is currently characterized by major over-capacity, and Ernst and Young (2012) predict that, by 2015, 180 solar module manufactures will go bankrupt, including more than 50 Chinese. Thus, while PV keeps expanding, the industry is going through a rough patch while the European market has both dwindled in size and become more protective. A trade war with China on top of this would do renewable energy or green growth no favors.

At a worldwide $88 billion in subsidies, renewables may seem expensive. However, the IEA (2012) estimates *fossil fuel subsidies* for 2011 to be a whopping $523 billion. And a country like Germany subsidizes every coal miner by more than $85,000. Thus, fossil fuels are subsidized to an extent that renewables can only dream about. Without these, the true cost of coal and petroleum might easily be twice what it is today (EREC and Greenpeace, 2007), even without including externalities like emissions. In Japan, Iida (*Japan Times*, 2007) has adamantly stated that the reason why nuclear has consistently ranked as the cheapest source of electricity is because hidden costs have been systematically excluded. If compensation costs were included, wind would most likely be competitive on price. Others have suggested that the main reason why renewables are not yet competitive is underfunding (Schilling and Esmundo, 2009).[9] In other words, the cost disadvantage may not be as obvious as is sometimes claimed; it has been greatly reduced from decades of technological progress, and it rests to some extent on the sheer political influence of powerful fossil-fuel lobbies.

A third point, however, is that the success of renewables, especially in Europe, is putting major strains on the electric grid. As ever more renewables are phased into the grid, grid regimes and regulations will have to change. In Europe alone the grid infrastructure may have to be upgraded by a hardly fathomable €1 trillion by 2020. This is far more than the utilities can realistically finance (*Economist*, 2013b).

This said, despite clouds on the horizon and hiccups in different markets, both wind power and solar power are growing strongly and will continue to do so. And we do know at least some things about the future with a greater certainty than in the past, giving us some grounds for prediction. Peak oil, climate change and technological progress are three factors that all strongly suggest that renewables will become more competitive – albeit, only if shale gas turns out to be less of a revolution than some have predicted. They will become more competitive because they are still not very mature technologies and can thus expect to see substantial technological improvements in the future. They will also become more competitive because greater scarcity, greater energy demand, and the end to 'easy oil' implies the continued rise in oil prices – although, again the newfound abundance of shale gas has on occasion threatened to send prices back below $100 per barrel. And climate change will (hopefully) lead to a stronger political realization that international and supranational measures to curb GHG emissions need to be implemented. FITs and carbon taxes would, for instance, greatly improve the competitiveness of renewables. And while again acknowledging the open-endedness of technological developments, it is difficult to conceive of a future in which renewables do not play a considerably more important role than today. This may not be enough to solve either energy or climate problems, but it will still be an important feature of our common future and such a common feature of the solutions to the problems faced by the countries discussed in this book that it deserves to be treated in a book format. Likewise, peak oil is bound to influence energy security deliberations, not just in Japan, China and Northern Europe, but in the rest of the world.

Renewables might be a major part of the energy security solution of the future. Thus, in the United States, one of the most eager proponents of renewable solutions is the Department of Defense, planning the world's biggest rooftop solar initiative as well as spending heavily on microgrids, smartgrids, advanced batteries and fuel cells, with the goal that future army bases consume only as much energy and water as they produce (Closson, 2013; *Powermag*, 2012). For the most part, however, energy security is still to a major extent about how to secure access to petroleum at reasonable prices for the foreseeable future. And, while at present the market secures this access at world market prices for the overwhelming majority of countries, it is not a given that this will be so in a future characterized by more pressure on ever-scarcer resources. Looking into the energy security strategies of Japan, China and Northern Europe makes perfect sense for a book like this, in particular when combined with renewables.

Rather than finishing this introductory chapter on a glum and downbeat note, however, while we should all agree that energy security and renewables are topics that will only become more pressing – and, that understanding the strategies and the political processes of different countries in this respect is of the utmost importance – it is also important to note that herein lies a major opportunity. As compared to the 87 million barrels of oil consumed per day, the amount of power produced by wind is the equivalent of roughly 2 mb/d, and from PV only 0.4 mb/d (Jaffe and Morse, 2013). This means that renewables are growing from a very small base, and they need to keep growing at a very rapid pace for many years, still, in order to make any significant contribution to the world's energy supply. But, it also means that there is still enormous room for growth in renewables. A structural transformation away from fossil fuels will have to happen at some stage or another, and there could be serious industrial benefits for those countries that make the transition earlier than others. Japan and China have both thought of renewables in an export perspective for years already. And while structural change is always a thorny and tenuous process that meets with resistance from those threatened by change, it is a necessary process of change. Ultimately, however, success from not just a national, but from a global, perspective is contingent on this transformation being made by all of us. This is a transformation that can only be accomplished by looking at the political economy of renewables and of energy security – by looking at the technological, the economic and the political in conjunction. It is the perspective that this volume seeks to provide.

Notes

1. Of the world's 10 largest companies (total revenue), six are fossil-fuel providers, one is an electricity company, and two are car manufacturers (CNNMoney, 2013).
2. In METI's 2010 revised Basic Energy Plan, nuclear was supposed to increase its share of electricity supply from 30 to 50 percent by 2030 through the construction of 14 new nuclear plants.
3. Thomas Edison patented a light bulb in 1879. Hiram Maxim started a light bulb company in 1878.
4. Kerosene is still in wide use today, primarily as fuel for jet engines, but also for instance for cooking and heating in a number of poor countries.
5. 115 mb/d by 2040, up by 34 percent from today, with natural gas increasing by more than 60 percent (Klare, 2013).
6. The Eagle Ford shale site in Texas, one of the biggest U.S. shale oil plays, has an annual decline rate that requires the drilling of 1,000 new wells a year, just to keep production flat (LMD, 2013).
7. Marques and Fuinhas (2012) suggest that national strategies should focus on renewables as export industries – which would be growth promoting – rather than on renewables as growth promoters – which they are not.
8. In 2012 the United States imposed a 31 percent tariff on 61 Chinese solar panel manufacturers, and 250 percent on another group of PV companies. The EU imposed an 11.8 percent anti-dumping tax, but following EU–China trade talks, the tax was replaced by minimum prices and quantity limits (*Economist*, 2012a; Ernst and Young, 2013).
9. Estimates on the potential progress of renewables typically plot performance against time. However, plotting performance against cumulative investment shows that wind power has exhibited far greater improvements per dollar invested than other sources of energy.

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Part I

Energy Security

2

What is Strategic about Energy? De-simplifying Energy Security

Gunnar Fermann

Modern and postmodern production and consumer societies rely on an abundant supply of energy to implement key policy goals. In pre-industrial society, the prevailing energy source was *biomass* as found in forests and marshlands From the 1830s, biomass was increasingly supplemented by coal. From 1900, coal was the world's dominant energy source, fuelling manufacturing processes and heating urban dwellings. The dominance of coal in the world's energy consumption lasted well into the 1950s, when the petroleum-fueled automobile was made broadly available in North America and, increasingly, also in other parts of the industrialized world. By the 1970s, a triad of fossil fuels – oil, coal and natural gas – was established as the backbone and prevailing energy mix of the world's energy supply (North and Thomas, 1976; Smil, 2010).

The interplay of availability, technology, market forces, and politics resulted in the dominance of fossil fuels in the world economy. By 2011, the relationships among geology, engineering, demand, and interest assertion had pushed the combustion of coal, oil, and natural gas to account for 87 percent of the world's energy consumption. In the process, fossil fuels strongly contributed to the unprecedented growth of the world economy in the past century, and unintentionally became the main ingredient of human-induced climate change (BP, 2012; IPCC, 2011; Klare, 2008; WEF, 2013; Yergin, 2011). Even though hydro-electrical and nuclear power generation supply the lion's share of the remaining 13 percent of the world's energy consumption, it is in the new renewable-energy sources (wind, solar, geothermal, tidal), and wind in particular, that the growth potential of non-fossil fuels has been the greatest: In the last decade, new renewables have grown 3.5 times while hydro increased by a modest 25 percent, and nuclear did not grow at all (BP, 2012).

At first glance, such numbers would seem to support the World-Watch Institute's prediction that wind power will become the 'fastest growing energy source ready to displace coal' (WWI, 1996). However, such a forecast underestimates the logic of scale: It is true that the installed capacity of new renewable energy sources have increased 3.5 times over the last decade,[1] and that coal has increased by 'only' 56 percent in the same period. However, this is just half the story (BP, 2012). The crucial part is that the growth in non-hydro renewables has been severely restricted by the modest baseline for growth, which at present is a miniscule 1.6 percent share of the world's energy consumption. Juxtaposing this share to coal, which accounts for 28.2 percent and has been growing in recent years, it becomes evident why 'coal grew 10 times more than new renewables' in absolute terms during the past decade (IPCC, 2012; WEF, 2013, p. 13). Add to this that from 2002 to 2011 oil and gas accounted for, respectively, five and three times more than new renewables to the growth in energy consumption (IEA, 2012), and the implication is hard to ignore: Fossil fuels in general, and coal in particular, are hugely predominant in fuelling the growth in global energy consumption, particularly so in the emerging markets of East and South Asia.

This chapter provides a study of the conceptual content of, and the empirical relationships between, energy as a strategic resource and issues of energy security. Several related questions are scrutinized: What characterizes strategic resources in general, and energy in particular? How may exploitation of energy contribute to economic development? How do the strategic attributes of energy interact with other factors to politicize and securitize energy issues? What conceptions of energy security pervade the energy discourse, and how may new and less-broadcasted aspects of energy security be included in a broader conceptualization of the phenomenon? I argue that, in order to identify and understand the real-life complexities of energy security (linkages, tradeoffs, risks, possibilities, win-win solutions), the phenomenon needs to be analyzed (a) at several levels, (b) from both security of supply and security of demand perspectives; and (c) with different time horizons in mind. Finally, I discuss the future role of new renewables, concluding that the logic of scale and present investment patterns indicate that the contribution of new renewables to world energy consumption will remain marginal in the medium term. This implies, inter alia that, to the extent that it will be dealt with at all, the long-term challenge of human-induced climate change will have to be addressed mainly by means of adaptation rather than mitigation of CO_2.

Energy as a strategic resource

What, exactly, is *strategic* about energy? One answer is already indicated above: modern states rely on the abundant supply of energy to implement key policy goals. These may relate to the economy at large, industry and labor, the transportation of goods and people, consumption patterns, social cohesion and political stability, external security, or the environment. The abundant supply of energy fuelled the Industrial Revolution and is a necessary – but by no means sufficient – condition for the emancipation of man from heavy manual labor, and the production of the surplus (time, food, goods, profits and services) that is required to lift populations beyond the threshold of minimal subsistence.

In general terms, strategic resources may be defined as resources without which it is almost impossible to conceive socio-economic development within a particular historical era (Negut et al., 2007, p. 18). In a similar line of reasoning, Stephen Van Evera suggests that a strategic resource is cumulative since 'its possession [or control] helps its possessor [or controller] to protect or acquire other resources' (1999, p. 105). This conception resonates with Robert Dahl's observation on domestic politics, that inequalities in the distribution of political resources (wealth, education, land, votes, military power, the right to make laws) can be cumulative and can generate new and further inequalities (1976, pp. 56–9). It follows that strategic/cumulative resources are crucial and sought-for precisely because they have the capacity to be converted into other sought-for resources. In other words, a strategic/cumulative resource is at the minimum an effective means to another end of crucial importance or, in its most perfect form, a universal currency with which several other critical resources can be acquired. In an effort to put some meat on the conceptual bones, it is prudent to pay a visit to the historical record (Fermann, 2009, p. 11).

Under the agricultural mode of production, prevalent in all civilizations up to the Industrial Revolution, the access to fertile soils and natural pastures was crucial for the feeding of populations as well as for sustaining powerful armies with the help of which new territories were conquered and ruled. Prior to the large-scale production of synthetic fertilizer and the engineering of high-yielding crops, the strategic resources of fertile land and water had to be conquered to provide a net contribution to the conquering state's resources. The competition for arable land and water is not a phenomenon of the past. Increasing populations in Asia, Africa and Latin America have led to an acute shortage of arable land and fresh water in many regions and seems to have been a significant factor in several conflicts, including those in Chiapas, Palestine, Peru, Rwanda, and Zimbabwe. In the first phase of the Industrial Revolution iron ore and cotton took on the attributes of strategic resources due to their indispensability for the production of machines, railways, ships and the clothing of a rapidly growing population (Diamond, 2005; Kennedy, 1987; Klare, 2002).

In the early 20th century, the Middle East became a region of strategic importance for the British, and not only because control over the Suez Canal secured the shortest sea route to India, the most valuable asset of the British Empire. Subsequent to becoming First Lord of the Admiralty in 1911, Winston Churchill – for both military and budgetary reasons – switched the fuelling of the Royal Navy from coal to oil by implementing (1912–14) 'the biggest naval building programme the navy had yet undertaken' (Jenkins, 2009, p. 9). This was not done primarily to achieve supremacy in the naval arms race with Germany in the North Sea and the English Channel, which by 1911 was already secured. Rather, it was done to safeguard Britain's colonial possessions. This presupposed Britain's continued global naval supremacy, which made it necessary to take advantage of the benefits in logistics, costs and operational speed that the conversion from coal to oil would bring (Keegan, 1988, p. 137, 2004, p. 66–7).

Relevant to our argument however, is the fact that Britain's decision to fuel her navy by oil made the control over the Middle East more crucial: The First World War made it both necessary and possible for Britain to take control over and exploit the oil-rich provinces in Persia (Iran) and Mesopotamia (Iraq) through her military presence in the Persian Gulf and a controlling share in the Anglo–Persian Oil Company (1908). By the late 1920s, French, Dutch and U.S. interests were also present in the region for exactly the same reasons – to secure a hand on the wheel controlling the new strategic resource fuelling the main instrument for the projection of military power, the petroleum-propelled blue-water navy. The Middle East had become a strategic area due to its abundance of oil, and the West's growing dependence on this substance (Dahl, 2000; Jenkins, 2009; Keegan, 1988; Roberts, 1995; Yergin, 2011).

Since the First World War, the strategic character of oil has become increasingly clear, as has the strategic role of the Middle East as supplier of this key commodity. Clearly, the usefulness of oil is not limited to warships. Oil is used for the locomotion of cars, buses, trucks, merchant ships, and planes all over the world and, along with coal and gas, is converted to other forms of energy (electric energy) utilized for the smelting of metals, the heating of buildings, and the running of all sorts of equipment for information technology. Moreover, hydrocarbons are the raw material for indispensable components and products, including synthetic fibres, plastics, paints, bitumen in the streets, drugs, and a host of items found in any modern household (Negut et al., 2007). In financial terms, and in terms of volume, crude oil is the single most-important commodity traded trans-nationally. This is because oil is so extensively used as energy source and raw material all over the world, but – as will be shown below – ultimately because there still is a huge territorial disparity between the main poles of consumption and production (BP, 2012; Energy Watch, 2013; IEA, 2012; IMF, 2012; WEF, 2013; WWI, 1996).

Finally, several energy sources have been key factors in technology-driven economic growth. While the utilization of waterfalls and rapids were essential for the development of the textile industry in the early Industrial Revolution, the growth impetus provided by investments in the building of railways for the development of the metallurgical industry would not have been possible without the abundant supply of coal. Even more prominent is the role of petroleum in the fuelling of vehicles, in the car industry, and in the development of a road-based infrastructure of transport. Prior to the global technological revolution in information and communication technology from about 1990, there were huge investments in vehicle-related industry and infrastructure development that provided the main engine of growth in the global economy for several decades of the 20th century (Moe, 2007, 2009; Reinert, 2007). Arguably, the most prominent example of energy and technology combining to facilitate economic growth is the development of the petroleum-fuelled combustion engine. This would have been inconceivable without the abundant supply of oil.

Rediscovery of politics in the energy discourse

The multiple realization that energy is a strategic resource of limited and increasingly more expensive availability, and that Western control over world energy markets is increasingly challenged, have led to a 'rediscovery of politics' in the European and American energy discourses that occasionally amount to fully fledged re-'securitization' of contentious energy issues (Buzan, et al., 1998; Godzimirski, 2009; IEA, 2006; Klare, 2009; Zittel and Schindler, 2007). When doubts arise about world energy markets being capable of providing sufficient energy, the downstream energy industry, customers and politicians, are reminded that markets for strategic resources inherently belong to a *political* economy with the cut-throat competition this implies.

The strong relationship between politics and the economic sphere of value-producing activities is assumed in political science's notion of politics as a struggle for power for the purpose of influencing the distribution of goods for the benefit of a particular group. This understanding of politics as an interest-driven activity and a value-distributing mechanism is reflected in Aristotle's advice that economics should be subsumed under politics (in Jowett, 1943). The economy is a *political* economy, and should be studied as such. Any attempt to analyze the one without the other is of limited value, since structures of power and authority in the real world are linked with markets and patterns of division of labor within and across countries. While energy is too important to be left solely to the discretion of the market and the key operators, it is undoubtedly also the case that powerful market actors, both on the supply and distribution sides, harness substantial leverage on energy-policy-making in many countries to such an extent that, in the case of the EU, it has undermined the European Commission's efforts to stimulate the development of a strong common EU energy policy and a unified foreign policy in its energy relations with Russia (Claes, 2009; Leonard and Popescu, 2007; Romanova, 2009; Westphal, 2009).

Arguably, this strong focus on energy as a security-relevant issue reflects the notion that for now the market–liberal paradigm has reached its zenith and is retracting. The seemingly apolitical vision of market liberalism perceives energy resources as any other commodity and trusts the market to secure an abundant supply, to assure effective use, and to limit environmental side effects. This ideology is increasingly supplemented by a more political realist understanding that energy is a strategic resource and that its availability and demand at sustainable prices cannot be taken for granted. In the perspective of realpolitik, 'asymmetrical interdependence' among energy-importing and exporting countries is likely to invite the exploitation of energy dependence for political purposes – whether dependence takes the form of relying too heavily on energy imports to fuel the economy, or on energy exports to finance import and balance public budgets. When a strong territorial disparity exists between the main poles of energy consumption and the main areas of reserves and production, both energy-importing and energy-exporting countries become vulnerable to relationships of 'asymmetrical interdependence'. Adding the spatial dimension to political realism makes for *geopolitics* (Keohane and Nye, 1977; Leonard and Popescu, 2007, pp. 7–10; MacKinder, 1904; Mearsheimer, 2001).

There are five take-home messages from the strategic conception of energy and the empirical flashbacks alluded to above: First, domestic energy sources do not satisfy the demand for energy in most industrialized countries (oil, gas, uranium in particular). Hence, in the medium term, import-dependent countries rely – to a greater or lesser degree – upon well-functioning *transnational* energy markets to satisfy their energy-needs.

Second, the sufficient and unobstructed supply of energy through international markets at sustainable prices cannot be taken for granted due to limitations on and risks to supply related to a host of technical, economic and political factors – such as 'peak oil'; blow-outs and technical gas-line disruptions; peaks and dips in the growth of the world economy; limited investments in the building of gas pipelines; the weakening of world energy markets due to the entering into of bilateral trade and investment agreements; economic sanctions and boycotts; and military hostilities within and between states (Klare, 2008; Yergin, 2011). When international energy-markets cease to supply predictable volumes of energy at acceptable prices, energy enters the domain of politics. Hence, the international energy economy should be perceived in terms of an international *political* economy of energy. In the present context, politics is about the peaceful or forceful competition/struggle for the distribution of the scarce and sought-for resource of energy and the revenues related to its production and use.

Third, this implies that the inherently political logic of international energy transactions cannot be properly grasped if public and scholarly debates are limited to the apolitical discourse of market economics, which assumes the proper functioning of the mechanism of supply-and-demand in price formation, and which emphasizes purely instrumental issues related to economic efficiency and revenue maximization. In a *political* economy of energy, sufficient demand and supply cannot be assumed, and political control over energy sources, and up- and downstream infrastructure becomes a necessary condition for *energy security* – whether understood in terms of security of supply or security of demand (Barton et al., 2004; Godzimirski, 2009).

Fourth, add to this the fundamental deficiencies of security and regulation in international politics ('anarchy', Waltz, 1979), which induce states to see international interaction as a struggle for power and survival, and which are only partially balanced by integrative patterns of economic interdependence at the transnational level (Keohane and Nye, 1977), and the concerns for security of supply and security of demand transform from an issue dealt with by market regulators applying policy instruments of law and economic incentives, to an issue of national security attracting the attention of security analysts and foreign policy decision-makers facing a more dramatic challenge: 'How to secure the sufficient supply of energy if neither domestic nor transnational energy markets do the job?'

Against this backdrop, energy security clearly is an issue deserving of the acute attention of the top strategic leadership of the state. To the extent that energy security cannot be achieved by means of reduced energy consumption and energy-substitution measures (net energy-importing countries), or less spending (net energy-exporting countries) energy security has to be dealt with within the domain of foreign and security policies. Here, great powers with extended political responsibilities are likely to treat energy policies as an instrument of war by other means, to paraphrase Prussian soldier and military theorist Karl von Clausewitz (1943).

Sources of tension and discord in the global political economy of energy

To what extent are structural conditions for conflict built into the global patterns of consumption and production of oil and gas? Are there any indications that natural resources, in general, and oil and gas, in particular, are frequent ingredients in the structural and motivational mix causing and triggering conflicts between and within states?

In financial terms as well as in terms of volume, crude oil is the single most-important commodity traded trans-nationally. This is because all over the world oil is so extensively used as an energy source and raw material, and ultimately because regardless of the surge in unconventional oil and gas in North America there still is a huge territorial disparity between the main poles of consumption and production in the world (UNCTAD, 2004; WEF, 2013). This structural 'misfit' in the spatial locations of oil production and consumption is amplified by the concentration of oil reserves in the Middle East (see Table 2.1). The largest technological, industrial and economic powerhouses of the world (EU, United States, China, and Japan) are dependent on oil imports, especially from Middle Eastern Organization

Table 2.1 Oil – territorial disparities in reserves, production and consumption (2011)

Share of World (%)	**USA**	**Canada**	**EU**	**Japan**	**China**	**Russia**	**Middle East and North Africa**	**Sum**
Oil reserves	1.9	10.6	0.4	0	0.9	5.3	50.4	*69.5*
Oil production	8.8	4.3	2.0	0	5.1	12.8	36.7	*69.7*
Oil consumption	20.5	2.5	15.9	5.0	11.4	3.4	10.3	*69.0*
GWP (PPP)[1]	18.9	1.7	19.4	5.6	15.0	3.0	4.9	*68.5*

Note: [1] Gross World Product (GWP) is the combined gross national product of all the countries in the world. Because on a global level imports and exports balance each other out, GWP equals global gross domestic product (GDP). In 2012, GWP totaled approximately $84.97 trillion in terms of purchasing power parity (PPP), and around $71.83 trillion in nominal terms (CIA, 2013)

Sources: BP (2012) and IMF (2012).

of Petroleum Exporting Countries (OPEC) countries, but also from countries like Russia, Venezuela, Algeria, Nigeria, Norway, Canada and Mexico.

International trade in natural gas is made possible (and restricted) by cross-border pipelines (over land and on the seabed), as well as by the more limited shipping of liquefied natural gas (LNG) between and within continents (Austvik, 2009). For natural gas, the pattern of territorial disparity is less evident than for oil. The largest consumer of natural gas, the United States is at present largely self-reliant, as is China. The opposite is the case for the EU and Japan which import some 60 and 100 percent of their gas consumption, respectively. The relative gas independence of China will be reduced over time as its gas reserves are exhausted (BP, 2012; Chabrelie, 2004; WEF, 2013). This is demonstrated by the efforts of China and Russia to build a gas pipeline from Eastern Siberia to China.

In most industrialized and energy-importing countries, gas accounts for a considerably smaller share of primary energy consumption than does oil and is more susceptible to competition from other fuels and technologies. Energy substitution and energy-conservation measures may weaken, and – along with other developments – even undermine a trend towards increased territorial disparity between regions of gas supply and regions of gas demand: In 2011, the EU consumption of natural gas decreased by 9.9 percent, an unprecedented drop. Across the Atlantic, U.S. gas production soared by 7.7 percent from 2010 to 2011. This is, along with some estimates and predictions, an indication of a commercial potential of unconventional gas resources (shale gas) in the United States and elsewhere (BP, 2012; IEA, 2012; U.S. EIA, 2012). This mix of developments is likely to decrease the energy–import dependence of North America in the short- or even medium-term, and increase the energy–import dependence of countries like China and Japan.

Table 2.2 Gas[1] – territorial disparities in reserves, production and consumption (2011)

Share of World (%)	**USA**	**Canada**	**EU**	**Japan**	**China**	**Russia**	**Iran**	**Qatar**	***Sum***
Gas reserves	4.1	1.0	0.9	0	1.5	21.4	15.9	12.0	*56.8*
Gas production	20	4.9	4.7	0	3.1	18.5	4.6	4.5	*60.3*
Gas consumption	21.5	3.2	13.9	3.3	4.0	13.2	4.7	0.7	*64.5*
GWP (PPP)	18.9	1.7	19.4	5.6	15.0	3.0	1.2	0.2	*69.9*

Note: [1]Conventional gas reserves. For an estimate of unconventional gas reserves (shale gas), see (US EIA, 2013).
Sources: BP (2012) and IMF (2012).

As for Europe, disputes on gas availability and terms of trade may intensify between Russia and EU member states if Russia fails to increase its gas production when the economic situation in Europe improves, and Russian commitments to provide (more) natural gas to China and Japan are to be acted upon (Baghat, 2006; Godzimirski, 2009; Noel, 2008; Noreng, 2009; Romanova, 2009; Westphal, 2009).

By now several factors have been identified as to why energy commodities such as oil and gas are sought-for and contested resources:

- Energy is a strategic resource with a cumulative character that makes energy convertible into other sought-for resources and policy goals (Dahl, 1976; Van Evera, 1999).
- Energy prices have in the longer haul soared due to scarcity resulting from economic growth – demand outstripping availability (IEA, 2006; Klare, 2009; Zittel and Schindler, 2007). The successful management of the global economic and financial system will stimulate the continuation of such a trend.
- There are patterns of territorial disparity between the main poles of oil consumption and the main areas of reserves and production that make both energy-importing and energy-exporting countries vulnerable to relationships of 'asymmetrical interdependence'. This is the geopolitical dimension of the international political economy of oil.

Add to these energy-specific structural ingredients the political realist notion that international politics is a struggle for power and survival among states that are prisoners of an unregulated and risky world order (Mearsheimer, 2001; Waltz, 1979), and several conditions for inter-state energy rivalry and armed conflict for the control of energy resources are met. The historical record suggests that the Second World War was fought partly to secure access to strategic resources.[2] Civil wars in Sudan, Mozambique, Nigeria, Rwanda, Congo, and Angola have been partly fuelled or motivated by control over oil or other natural resources. Furthermore, it is likely that the concern for control over oil was important in the motivational mix behind the 1980–88 Iran–Iraq War, the 1990–91 Gulf War, the 2003 U.S. intervention in Iraq, and the North Atlantic Treaty Organization (NATO) campaign to assist the Libyan rebels to force the Gaddafi regime out of power in 2011. The same motivation was clearly present in Britain's rush to occupy the Mosul oilfields in Northern Iraq during the last days of the First World War – at the expense of the Ottoman Empire and Iraqi nationalist ambitions (Bricker and Shamoo, 2007; Chomsky, 2008; Jenkins, 2009; Kaldor et al., 2007; Klare, 2001a, b, 2002; Kretzmann, 2009; McKillop, 2008; Negut et al., 2007; Roberts, 2004; Rutledge, 2005; Times Online, 2007).

However, one should not assume that violent conflicts over resources between and within states are inevitable. The causal and motivational links between resource-plenty/resource-scarcity and violent conflict are complex: Violent conflict behavior between states can be traced back to several factors at different levels of explanation, as well as through many chains and links of causation. Furthermore, decisions about waging war usually require the support of more than one motive in order to attract the support of domestic and international allies, which is necessary to build winning coalitions (Fermann, 2013). Still, there is mounting support for the hypothesis that global scarcity of natural resources in general, and oil in particular, may become an even more prominent part, than in the past, of the causal and motivational cocktail of reasons that move man to instigate coercive action (Arnson and Zartman, 2005; Bannon and Collier, 2003; Galtung, 1982; Homer-Dixon, 2009; Klare, 2008, 2009; Renner et al., 1991; Van Evera, 1999).

Energy security matrix: towards an extended conception of energy security

Issues of energy security originate directly from the strategic attributes and territorial disparities of energy discussed above. In particular, energy security relates to the experience that the abundant supply of energy is a precondition for technological and economic development and, thus, for the host of first-order policy goals served by successful technological and economic change. Unlike identity and arguably also power, which are phenomena that are defended and sought for as ends in their own right, questions of energy security are related to the *instrumental* character of energy as a strategic means to reach first-order policy ends in realms functionally related to energy. To the extent that energy is a scarce resource; a cherished source of income; a prerequisite for treasured ways of life, social cohesion and political stability, and is susceptible to being used as a means of extracting political concessions, energy issues are bound to be read through the lens of security. This is more so since the global spatial location of energy consumption only partially overlaps the physical location of energy reserves and energy production. If energy relations between exporters and importers of energy commodities in addition are complicated by disputes on terms of trade, political conflict, cultural abysses, or a political mentality of unlimited ambition, the strategic attributes of energy are likely to invite the fully fledged securitization of energy issues.

Given this backdrop, what aspects of reality should be included in the concept of energy security? Aside from the fact that energy is a means to reaching a wide range of crucial policy goals, *how is energy security to be understood*? The predominant energy security discourse is biased on the concerns of import-dependent and energy-intensive economies preoccupied with safeguarding of the abundant and uninterrupted supply of oil and gas from faraway places at sustainable prices – while there is growing pressure from emerging economies to increase their share of world energy consumption. For instance, Barton et al. see energy security as a 'condition in which a nation…has access to sufficient energy resources at reasonable prices at the foreseeable future free from serious risk of major disruption of service' (2004, p. 5). The European Commission has defined energy security as 'the ability to ensure that future essential energy needs can be met…by calling upon accessible and stable external sources' (ECC, 2011). The IEA (2009) understands energy security in terms of 'the uninterrupted physical availability [of energy] at a price which is affordable'. Finally, for Jamie Shea (2006), former director of political planning in NATO, energy security is mainly a question of dealing with terrorist attacks, regional conflicts and political blackmailing that can threaten the secure flow of energy to NATO member states.

This highly relevant, but still limited understanding of energy security as security of supply brings to mind the dominating and limiting discourse of the Cold War, when security was perceived as the state's capacity to protect itself from military attack (Buzan et al., 1998). Clearly, there is more to security than military threats to the state, and there is more to energy security than security of supply (Doran, 2009; Luft and Korin, 2009).

A huge body of literature shares the security of supply focus on energy security, if for no other reason that industrialized countries – with the notable exceptions of Canada, Russia and Norway – are dependent on the import of oil, gas and uranium to cover their energy needs. However, the security of supply approach does not exhaust this multifaceted phenomenon. This section will elaborate on a more comprehensive conception of energy security, accounting for the symmetrical, multilevel, and temporal aspects of issues of energy security. I argue that energy security is a *matrix* of only partly complementary concerns related to *whose* energy security is addressed, *what level of analysis* is chosen, and *how far into the future* we are looking.

The supply-and-demand sides of energy security

Security of supply relates to the energy security concerns of import-dependent economies such as the EU, the United States, Japan, and, increasingly, China.

The EU may serve as an illustration. The political economy of energy in Europe is defined by a large majority of states being heavily dependent upon the import of energy from a limited number of energy producers located mainly outside the EU, and by the relative failure of the EU to develop a strong common energy policy capable of effectively counteracting the vulnerabilities arising from oil and gas import dependence.

The EU imports half of its energy from abroad (mainly from Russia, Norway, the Middle East, and Africa), and this share is forecast to rise to 65 percent by 2030 if no action is taken. As the EU has only 0.5 percent and 1.6 percent of the world's proven oil and gas reserves, the EU's dependence on oil and gas imports is estimated to rise, respectively, from 82 and 57 percent in 2006, to 93 and 84 percent in 2030 (BP, 2008; Claes, 2009).

The implications are serious. Increased import energy dependence is obviously not the right response to a future offering cut-throat competition for energy from emerging economies (for instance China, India, Brazil) and an empowered Russia more prone to manage energy relations with Europe not through the prism of EU law and rules for economic exchange, but rather through the zero-sum glasses of geopolitics (Romanova, 2009; Waltz, 1979; Westphal, 2009). This could mean that the EU will have to pay considerably more for its future energy imports. In a worst-case scenario, the EU will increasingly fall prey to political blackmailing from abroad and be weakened by the centrifugal forces – originating at different levels within the EU – wrestling the glue out of the community so as to reduce the EU political and economic project into a mere token of unity.

Typically, security-of-supply strategies focus on the capacity of energy-importing countries to control the continuous access to energy at reasonable prices from energy-exporting regions of the world by means of coercion, investments, aid, economic integration, diversification, and so on. While control over foreign sources and chains of supply are crucial, there is no reason why import-dependent countries should limit their approaches to this. The implication of an approach that rather insists that 'energy security begins at home' (Rutledge, 2005, p. 7) is to reduce energy dependence by means of energy substitution and energy conservation. Japan is among the leading countries in this regard, as she ought to be, with no oil or gas resources of her own (IEA, 2008, p. 53). The pressure on Japan to increase energy conservation and energy substitution efforts has soared tremendously since the 2011 tsunami and the shutting down of several nuclear reactors. This is the most serious challenge to Japan's energy security since the Organization of Arab Petroleum Countries (OAPEC) used the 'oil weapon' in the 1970s (Fermann, 1995). As to the EU, history shows that EU energy policy-making may be described as an instance of too little too late (Andersen and Sitter, 2009). This must change if the EU is to take its future energy security seriously. Even more ambitious programmes for energy substitution, energy conservation, and energy-technological research are required.

The flip side of security of supply is *security of demand* and addresses the legitimate security concerns of energy exporters. More specifically, security of demand relates to the concerns of major energy-exporting countries like Saudi Arabia, Russia, Norway, Nigeria and Venezuela, which depend on the uninterrupted demand for oil and gas at high enough prices to finance necessary imports, investments in production capacity and distribution facilities, the functions of the state, and long-term economic security, as well as to secure a degree of social cohesion and political stability. The worst-case scenario for an energy-exporting country is to depend on a single energy commodity for its export earnings when there are only a few takers of the commodity, having little influence on the terms of trade, and suffering difficult political relations with its largest trading partner. A best-case scenario would be for the energy-exporting country to rely upon a broader mix of commodities for export (energy and other), spread risks by relying on several energy markets, and enjoy friendly relations with all its major trading partners. Norway's and Russia's energy relations with the EU serve as illustrations of such security-of-demand concerns.

Since Norwegian oil-production started on the North Sea Ekofisk field in 1971, the petroleum sector has soared to the extent that in 2009 it accounted for 26 percent of annual Norwegian investments, 22 percent of GDP, and 47 percent of exports (IEA, 2011a, p. 51). Furthermore, the size of value-creation in the Norwegian petroleum sector is 3 times higher than in the land-based industry, and 18 times the value-creation of the primary sector (MEP, 2009; SSB, 2009). Petroleum exports have secured a comfortable surplus for the Norwegian trade balance. To avoid inflation, spread risks, and prepare for a future with less petroleum income a large share of income from petroleum exports has been invested abroad by the Norwegian Bank Investment Management. In May 2014, the value of the petroleum-based Norwegian Government Pension Fund was NOK 5,165 billion (€642 billion), and is forecast to increase to NOK 7,400 billion (€919 billion) by 2030 (Norges Bank, 2013; Stortingsmelding, 2010–11).

For Norway, the importance of energy as a source of income and a generator of technological innovation and industrial development is obvious. However, Norway's energy relations with Europe and beyond also have international significance: Norway is not a member of OPEC, but is the third-largest exporter of gas and oil in the world, behind Russia and Saudi Arabia (IEA, 2011b). Add to this that Norway depends on demand from EU member states for 80 percent of its oil exports and almost all its gas exports, and Norway's high dependence on continued European energy demand is undoubted. In the process, Norway has invested some NOK 2,500 billion (€310 billion) in production facilities and gas pipelines to the UK and the European continent (EU Delegation, 2012). Hence, there is nothing lukewarm or non-committal about Norway's energy relations with Europe.

Does this make Norway vulnerable to weakened EU energy demand? Is there a risk that European demand for Norwegian oil and gas is likely to decrease and threaten security of demand? The brief answer is a conditional 'no': First, Norway is considered a provider of energy of first choice by the EU due to short transport distances, reliable supply, and friendly and close political relations. Second, in a world of energy demand outstripping supply, European appreciation for Norwegian oil and gas will soar, even more so in the context of continued disruptions in the Russian supply of gas to EU member states.

Then it should be recalled that (a) Norway does have other legs to stand on for 50 percent of her export revenue (fishery products, metals, electricity, ships); (b) Norway purchases some 70 percent of her imports from the EU (Statistics Norway, 2009); and (c) is closely linked to the EU through the 1994 European Economic Agreement. Hence, the relationship between Norway and the EU may better be described in terms of integration than interdependence. In such an international environment, there is little room for hostile relations. There have been few if any signs of political securitization of energy relations between the EU and Norway, if for no other reason than that they consider each other reliable energy partners on good terms on most issues (Buzan et al. 1998). However, Norway is sensitive to fluctuations in gas prices, which tend to follow the price of oil on the world markets, and plans for alternative avenues of export (LNG to transatlantic destinations) have, since 2005, been counteracted by the surge in shale gas in the United States. Decreasing gas consumption in the EU has also put pressure on Norway renegotiating gas-delivery agreements with takers such as France and Germany (BP, 2012, p.15, 27).

I discussed the dependence of the EU on Russian energy above in the context of security of supply and concluded that the EU is vulnerable to disruptions in the transfer of Russian gas, and to Russia using EU gas dependence to extract political and economic concessions. However, this does not imply that Russia holds all, or even the most valuable, bargaining cards in relation to the EU, or that Russia does not have her own legitimate security issues to worry about related to security of demand. Most notably, Russia is even more dependent upon European energy markets than the EU is on Russian energy: 78 and 98 percent of Russian oil and gas exports are headed for Europe, while EU dependence on Russian gas is in decline as a share of EU gas imports and consumption (Kovacovska, 2007; Noel, 2008; Romanova, 2009). With the lion's share of Russian oil and gas exports heading for the EU, it is worrisome for Russia that energy exports account for more than two thirds of total Russian export earnings (68.4 percent in 2007), and that Russia was the country that suffered most from the 9.9 percent drop in EU gas consumption in 2011 (BP, 2012, p. 4).

Moreover, Russian trade with EU member states accounted for 53.4 percent of Russia's export earnings in 2007, while EU exports to Russia only accounted for 7.2 percent of EU's total export revenue (DG Trade, 2008). This implies – everything else being equal – that Russia is much more dependent upon trade with the EU than the EU is on trade with Russia. It also implies that renewed Russian great-power ambitions have a narrow and vulnerable economic foundation and that the financing of the Russian state very much depends on its European relations in general and, in particular, on developments in global energy markets, which are largely outside Russian control.

What speaks in favor of Russia is the strategic nature of the energy commodities Russia can provide, and the willingness of European member states to strike bilateral energy deals with Russia at the expense of the Community as a whole. There are two more elements in the Russian strategy: One is the Russian attempt to undermine Western efforts to develop alternative sources of gas supply from Central Asia, and the viability of the Nabucco gas-pipeline in particular (Petersen, 2009). The other is the Russian effort to find alternative outlets for her energy exports. The deals struck between China and Russia on trans-boundary pipeline projects in the East are likely to become a case of successful export diversification if implemented (*China Daily*, 2009; Godzimirski, 2009). The recent shutting down of Japan's nuclear power-generation industry is almost certain to increase LNG purchases from Russia.

Since 2003, Russian policy has been to strengthen influence over and partly nationalize the energy industry. While this has given the state more control over energy assets, it has also contributed to under-investment in oil and gas exploration and production, as well as to scant investment in pipeline infrastructure. This represents – along with increased Chinese and Japanese demand for Russian energy – a challenge to the EU's security of supply. It is also a challenge to Russian security of demand further down the road as Russia's energy customers in Europe will have to take measures towards import diversification, energy substitution and energy conservation in order to adapt to declining Russian energy exports.

In such a long-term perspective, Russian energy security of demand may be better served by inviting and safeguarding foreign investment in the Russian energy sector, and to view stronger economic integration between the EU and Russia less as a threat to national sovereignty than as an opportunity to prosper through a broader and deeper economic interaction with European countries. The historical record indicates that even the traditional ambitions of great powers as seen through the lenses of realpolitik cannot be fully nurtured in an export-oriented economy primarily based on the shipment of energy commodities, steel, nonferrous metals, timber, and an assortment of highly sophisticated weapons. Much speaks for the argument that on the global scene of the 21st century, 'greatness' has taken on added meaning and is awarded to those polities and political elites that are capable of navigating with the sophistication, patience and self-confidence necessary to make themselves useful, respected and trusted in an interdependent and increasingly integrated world.

Multi-level and temporal approaches to energy security

Both energy-importing and energy-exporting countries have legitimate energy security concerns. However, sub-classes of state actors such as energy-exporting Norway and Russia, and energy-importing Germany, China, and Japan do not exhaust the range of possible answers to the question of 'whose energy security'? For several research purposes the energy concerns of the state may be too crude an analytical framework to capture the full essence of energy politics, too simple to bring about necessary policy adjustments, and too restricted to reflect the wider range of legitimate concerns embedded in the concept of energy security. It is necessary to distinguish among several levels of analysis to grasp the full dynamics of energy security in the political economy of energy:

- Global energy security
- Regional energy security (for example European, East Asian)
- Energy security at the level of the state (security of supply and security of demand)
- Energy security at the sub-state and societal level (for example, regions, unions, energy companies with varying degrees of trans-boundary interests and commitments)
- Local energy security (for example the level of the local community, households and the individual).

From a social-science research perspective it is interesting to identify and better understand (a) the main structures and key actors influencing energy policy-making at different levels, (b) the mechanisms (political institutions, markets, formal and informal networks) through which these actors interact and influence one another within and across levels, and (c) the energy policies, behavior and macro trends that are reproduced and changed as a result of the dynamic interaction between political and economic structures and actors, across levels and polities.

Furthermore, it is worth investigating the conditions for and the extent to which different considerations of energy security, originating at different levels of analysis, may be harmonized and mutually strengthened. The difficulty of aligning these conflicting levels of energy security goes a long way toward explaining why the EU has failed to develop strong common energy policies which, in turn, has weakened the EU's bargaining power in relation to some of its main energy trade partners. The bilateral efforts of Germany and Russia to build a gas pipeline on the seabed of the Baltic Sea clearly have made a positive contribution to Germany's security of supply in the medium term and Russia's security of demand. However, it also simultaneously contributes to undermining the EU's capacity to speak with one voice in its energy dialogue with Russia.

Discord may also arise between the foreign-policy interests of the state as a whole and the more narrowly based interests and loyalties of major energy companies within a country. For instance, the Norwegian national petroleum company Statoil's conception of energy security is ultimately rooted in the interest of securing continued growth and creating value for its shareholders. This has led the company to make controversial investments in Angola (human-rights issues) and Canada (environmental issues) that may not reflect well on Norway's image abroad, and are at odds with Norway's collective self-conception as a nation built on liberal political values and sustainable development. However, in politics there are always tradeoffs, and one must assume that the Norwegian government, which owns the majority share in Statoil, supports the company's internationalization efforts. There may be several reasons for this. One is obvious – the additional revenue from Statoil's continued growth. The other is more subtle: By supporting the expansion of Statoil's petroleum activities abroad the government may hope to better control CO_2 emissions from petroleum production in Norway, and thus increase the possibility that Norway fulfils her abatement commitments under the international climate change regime. To the extent that this is the case, the internationalization of Statoil would not only make a contribution towards harmonizing economic and politico-environmental concerns for Norway within the strictly territorial conception of emission responsibility pervading the 1997 Kyoto Protocol (Fermann, 1997a). It would also ease the potential conflict between *Statoil*'s narrower conception of energy security serving the economic interests of the shareholders, and the Norwegian government's broader energy security agenda where energy policies need to

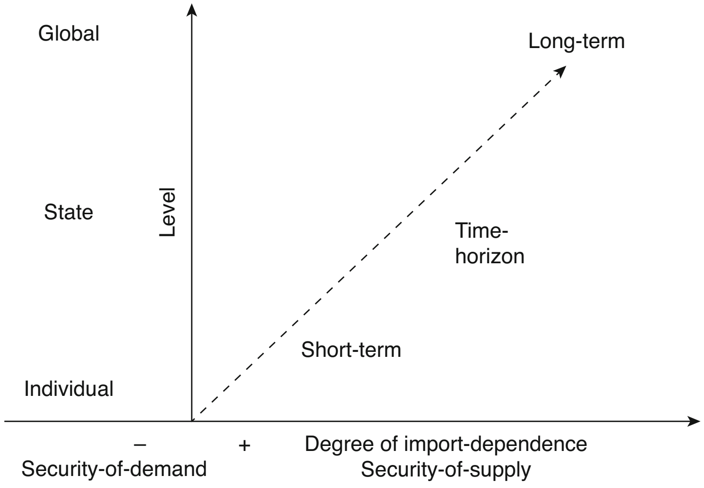

Figure 2.1 Three-dimensional conception of energy security

somehow accommodate or be harmonized with goals related to the environment, the implementation of abatement commitments, and to preserve the credibility of successive Norwegian governments in the eyes of the domestic public opinion and the international community.

A proposal for a broader conception of energy security is not complete without taking different time-frames into account. Indeed, in order to speak precisely about energy security it is not only necessary to ask *what* goals energy may be instrumental in serving (for example economic, employment, great-power ambitions, environmental), and *whose* interests energy security are geared to serve (actors and institutions at different levels): we also need to know *when* – that is, within what time-frame – energy security is to be accounted for. This is an invitation to take into account the accumulated long-term effects on issues of energy security from a particular policy or investment pattern. For the present purpose, the following temporal categories provide adequate resolution:

- Short-term (within the election period)
- Mid-term (a generation into the future)
- Long-term (several generations into the future)

A particular policy's contribution to energy security may not only be considered differently by actors and communities at different levels (global, regional, state, societal, and individual), but whether a policy of continued investment in fossil-fuels technology (like carbon capture and storage), exploration, and production makes sense (economically, socially, environmentally) is likely to depend also on the extent to which longer-term effects of the policy are accounted for. Is it, for instance, in Germany's long-term interest to increase its dependence on Russian gas and enter into bilateral energy agreements bypassing the EU? Is it in the long-term global interest that Norway invest so much in the prolongation of the petroleum era both at home and abroad? Indeed, is it in Norway's and Statoil's long-term economic self interest that processes of energy conversion and diversification towards renewable energy sources are not speeded up? When is it in the best long-term interest of a petroleum company to transform into a more broadly based energy company, and start investing in alternative energy sources?

Such questions are hard to answer, but should nevertheless be asked in terms of varying time-frames. The predominant discourse on energy security is focused on the present, short- and mid-term. However, it cannot be taken for granted that a sensible policy for the short- and mid-term equals a rational policy for the longer term.

The case of human-induced climate change highlights the host of tensions that may arise between shorter- and longer-term considerations of energy security. Due to the strong functional linkages between the problem of human-induced climate change and energy production, conversion and consumption (fossil fuels generating CO_2 emissions), present energy choices strongly influence future global emissions of CO_2, the concentration of greenhouse gases in the atmosphere, climate change and sea level rises, and subsequently the economic, social and political costs in lost GDP growth, in human suffering, and in increased conflict due to food shortages, competition for land and increased migration (IPCC, 2011). More than any other contemporary challenge, human-induced climate change offers global and long-term dimensions to the issue of energy security which in a radical sense challenges the internationally community to cooperate effectively on a global scale and with a longer time horizon (Fermann, 1997b; Tønnesson, 2009).

Conclusion: new renewables and energy security – Quo vadis?

Present energy research and investment patterns are the crystal balls within which the future of the international energy economy may be illuminated. One take-home message is that the promising future of new renewables is by no means certain, or even likely in the medium term. With her ambitious goals for energy substitution, the EU and particular EU member states are pushing for the further increase of renewable-energy production. But the EU is not an emerging market, and the argument can be made that the EU does not really have a common energy policy (Claes, 2009, p. 42). Rather, the EU is a pseudo-state and a common market losing political cohesion and shares of world GDP year by year.

More than anything else, China's tremendous economic growth is fueled by domestic sources of coal as well as by cheap capital and available markets overseas. Also, China's multiple moves to secure oil from Africa, the Middle East and South America and, increasingly, natural gas from Russia and LNG from Qatar and Australia, demonstrate that in Chinese energy-planning fossil fuels are in for the long haul.

Furthermore, the huge tar-sands operations in Alberta, Canada, and the rapid increase in shale-gas extraction ('fracking') in the United States have reduced these countries' short-term dependence on more expensive energy imports (IEA, 2012; US EIA, 2013; WEF, 2013, p. 21). At least in the short term, these new domestic sources of unconventional oil and gas are likely to reduce the economic incentives for the further development of renewable energy technologies, sources and facilities (IEA, 2012; US EIA, 2013). However, if recent reports on extremely high decline rates of shale-gas reservoirs, and dropping profits in the fracking business are confirmed (*New York Times*, 2011; OILPRICE.COM, 2012; Richter, 2012; *Wall Street Journal*, 2012), a large volume of unconventional gas at reasonable prices in the United States is probably unsustainable in the medium and longer term. If it were not for the availability of reasonably priced coal, the bursting of a shale-gas bubble in North America might provide the incentive for the relative growth in electricity production based on renewable energy sources in the United States. However, with present regulations and technology, price relations favor the increasing demand for coal over new renewables in most states in the United States.

Finally, it remains to be seen to what extent Japan's decision to close down tens of nuclear reactors for maintenance subsequent to the 2011 tsunami will become permanent (BP, 2012; *Guardian*, 2012). Some of the loss is likely to be replaced by renewables and by the 'fifth energy source' in which Japan is one of the world leaders – energy conservation. However, recent developments indicate that the lion's share of the energy deficit resulting from the closing down of old reactors and the delaying of plans for new ones will be met by coal, oil and LNG imports (BP, 2012; WEF, 2013).

Hence, the future of the world's energy economy would seem to be cast mainly in grey and black, with just a hint of green (IPCC, 2012). That is, unless some revolutionary energy technology turns up that is allowed to instigate a process of creative destruction worldwide that transforms the political economy of energy.

At present, the main technological breakthroughs have been happening in fossil fuels, consolidating the traditional state of affairs: By unlocking huge deposits of oil and gas from sands, shale and deep waters in Canada, the United States, and the Gulf of Mexico, fossil fuels' technology has created new barriers to a breakthrough for renewables – at least in the short term. The huge deposits of coal that fuel much of China's growth also contribute to offering the widespread commercialization of new renewables an uphill battle (Yergin, 2011, pp. 244–65). Such developments have contributed to enhancing the energy security of the United States and China in the short or medium term. However, the logic of scale, price relations, and the force of present investment patterns indicate that the contribution of new renewables to world energy consumption will continue to be marginal. This implies, inter alia, that the long-term challenge of human-induced climate change will be addressed mainly by means of adaptation rather than mitigation of CO_2 – that is, to the extent that it will be dealt with at all. In such a global, long-term scenario the world has yet to find a sustainable solution to this, the widest conception of energy security. In this perspective, the dominant share of fossil fuels in world energy production and consumption makes energy a part of the problem, rather than a key to a solution.

Notes

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1. That is, an average of 26 percent a year.
2. The German *Lebensraum* policy was partly a reaction to the successful Western embargo on Germany during the First World War. Japan interpreted its attack

on Pearl Harbour as a defensive reaction to the on-going Western embargo on Japanese supplies of oil and raw-materials from British, French and Dutch colonies in Southeast Asia.

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3

The Energy Security of Japan after Fukushima 3/11

Frank Umbach

Introduction

Energy (supply) security has always been a major security concern of Japanese governments, both before and after WWII. Securing access to raw materials and oil, for instance, drove Japan into WWII. As the third-largest economy in the world, the fourth-largest energy consumer, the third-largest oil consumer and importer, the second-largest coal importer as well as the world's largest LNG importer (already before the Fukushima nuclear catastrophe in 2011), Japan's lack of domestic energy resources, has determined the country's energy policies domestically as well as driving its energy foreign policies abroad. The expansion of nuclear power since the oil crisis in 1973–74 is the result of Japan's heavy dependence for oil and LNG from the Middle East, which accounts for almost 90 percent of its imports.

On March 11, 2011, a devastating earthquake of magnitude 9.0 on the Richter scale, with an ensuing 10-meter tsunami caused the loss of 25,000 people dead or missing as well as the destruction of 160,000 buildings. The earthquake and tsunami also triggered an accident at the Fukushima Daiichi nuclear plant 230 km north of Tokyo, and resulted in the release of regional radiation. The nuclear meltdown began several hours after the tsunami hit the coast, but the meltdown was not officially disclosed until nine weeks later. Only in October 2012 did Tokyo Electric Power Company (TEPCO) finally officially admitted its failings by taking stronger measures to prevent the disaster from cascading for fear of inviting lawsuits or protests against its nuclear plants. But in TEPCO's view, the catastrophe was not a 'man-made disaster' and not an incident which could be anticipated and prevented. Until then, TEPCO had refused to adequately fix a series of problems in order to maintain its nuclear safety myth. It had argued that the tsunami was larger than predicted and that the nuclear disaster should be considered as an act of nature for which the company should not be held responsible (*NYT*, 2012a). But an official Diet investigation blamed the Fukushima disaster on systemic collusion between industry, government, and the regulator – all part of the so-called 'nuclear village' advocating nuclear power and creating the Japanese safety myth. As a result, the Japanese public lost faith in the future of nuclear power despite the fact that the nuclear phase-out policy will cause an estimated loss of 3.6 percent of GDP and destroy almost 200,000 jobs (*Economist*, 2011).

Before Fukushima, Japan had 54 nuclear reactors with more than 45 GW of installed capacity, constituting the world's third-largest civilian nuclear power programme after the United States and France. In 2010 these reactors supplied 30 percent of the country's electricity demand, accounting for 13 percent of total primary energy supply. This made Japan the world's third-largest consumer of nuclear power (after the United States and France).

The importance of nuclear in the future energy mix had been documented in Japan's national basic energy plans of 2003, 2006 and 2010. But, despite official plans to expand nuclear power to 43 percent of total electricity output as early as 2015, only four new reactors were under construction. Tokyo's energy plans called for growth of nuclear power as a way to increase energy independence and to reduce its national emissions of greenhouse gases. The safety and security of Japan's nuclear plants did not play a prominent role in those concepts. Originally, the government and TEPCO planned to build 14 new reactors by 2030, which would have raised the share of nuclear-generated electricity production and other minor sources of clean energy resources from 34 percent in 2009 to 70 percent in 2030 (Onishi and Belson, 2011).

From the perspective of most Japanese energy experts in government, ministries, industries, and academia, the importance of nuclear in Japan's energy mix has never really been questioned because it served all three objectives of the energy triangle, namely: energy-supply security (reduction of unstable energy imports), environmental/climate targets and the economic competitiveness of its entire industry. In their view, without nuclear power Japan can never realistically hope to come close to the Kyoto agreement targets and decreasing its high dependence on politically unstable fossil fuel imports.

With its limited fossil fuel resources, Japan was only 16 percent energy self-sufficient at the beginning of 2011. Before Fukushima Japan already had one of the highest energy security risk indexes of the developed countries despite the fact that it has one of, or even the best, energy-efficiency standards in the world. Its average energy security risk was about a third higher than the OECD average over the last 30 years.[1] With no available significant domestic fossil fuel resources at all, it had the second-highest (or second-worst) average risk score of the period between 1980 and 2010. But thanks to its nuclear power programme and its efforts for enhancing energy efficiency, its risk level in 2010 was lower than its 1980 level (Institute for 21st Century Energy/U.S. Chamber of Commerce, 2012, pp. 8–9, 42–43).

Before the Fukushima disaster, Japan was the only non-nuclear weapons state which still had a full fuel-cycle infrastructure, including enrichment and reprocessing of used fuel for recycling. In order to reduce Japan's dependence on imported uranium, in 1992 Tokyo started reprocessing spent nuclear fuel at a new mega-facility in Rokkashomura in Aomori prefecture. Since the facility's construction, the government and utility companies have invested more than $20 billion in it. The facility has drawn international concerns about nuclear weapons proliferation (even in the United States), because it could also be used for enriched nuclear weapons programmes. Moreover, the nuclear weapons taboo in the public declined during the last decade as foreign and security experts have openly debated the pros and cons of a Japanese nuclear weapons capability in light of the North Korean nuclear threat as well as the expanding nuclear arsenal of China and the deteriorating bilateral relationship with Beijing (Umbach, 2007). Since Fukushima, however, the reprocessing facility has been practically mothballed.

After Fukushima, Japan's energy policy is once again at a crossroads. This chapter analyzes the nuclear disaster in Fukushima and explains the nuclear safety myth. In the context of its traditional energy policies and its energy insecurity, the chapter also offers some contradicting perspectives for the question of whether nuclear power still has a future in Japan. The chapter then analyzes the short-term impacts, such as rising LNG imports and the resulting vulnerabilities for Japan's overall energy security. Finally, it also offers perspectives for expanding renewable energy sources (RES) and the liberalization of its energy markets.

The Fukushima catastrophe and the future of Japan's energy policies

The Fukushima nuclear accident: failures, explanations and the nuclear safety myth

Fukushima was a triple catastrophe: The final meltdown of the Fukushima Daiichi nuclear plant was caused by a massive earthquake and by an unusual high tsunami hitting northeast Japan on 11 March 2011. But earthquakes are a fact of almost daily life, as Japan is hit by one every three minutes on average. Even larger earthquakes, beyond 6 on the Richter's scale, repeatedly shake the island nation. Advances in seismology have revealed active fault lines under or in the vicinity of nearly all of Japan's nuclear plants. In 2007, a 6.8-magnitude earthquake damaged the Fukushima Daiichi plant and caused radiation leaks. TEPCO had to admit that it had known about the existence of a 12-mile-long active fault line in the nearby sea. But the company had concealed the fact and marginalized its implications for the safety and security of its nuclear plants (*NYT*, 2011e).

The historically high tsunami caused the world's worst nuclear crisis since Chernobyl in 1986. It knocked out 12,000 megawatt (MW) of electric-generating capacity and triggered another triple impact of meltdowns, massive evacuations and decontamination work that will take decades to complete. Other energy infrastructures such as the electrical grid, refineries, oil and gas-fired plants were also affected.

The 'nuclear village' had never imagined a scenario in which it would lose control of the huge six-reactor Fukushima plant as a result of a natural disaster. Despite many smaller previous accidents, neither the 9/11 terrorist attacks in New York and Washington, D.C., nor the Indian Ocean tsunami in December 2004 were seriously analyzed by Japan's nuclear village with respect to the safety and security of Japan's nuclear power plants. International recommendations made after 9/11 by the U.S. Nuclear Regulatory Commission (NRC) were similarly ignored, as were those from the International Atomic Energy Agency (IAEA) and other international organizations, including expert groups (Lippert, 2012a).

By 2006, Japan's Ministry of Economy, Trade and Industry (METI), the Nuclear and Industrial Safety Agency (NISA) and TEPCO knew that several nuclear plants, including Fukushima Daiichi, could experience a total loss of power if their buildings were hit by a tsunami just one meter higher than ground level. Still, NISA did not order the utility companies to enhance the safety and security of the country's nuclear power plants. It simply asked TEPCO to improve the safety of a reactor cooling pump, but TEPCO found it 'technically difficult' and ultimately did nothing.

In July 2007, another massive earthquake at 6.8 on the Richter's scale caused an incident at what was the world's largest plant in terms of electric power output – the Kashiwazaki Kariwa nuclear plant (located in the towns Kashiwazaki an Kariwa in Niigata Prefecture) – leaking radioactive waste into the ocean and the air and disrupting electricity and water supplies. Four reactors were offline for maintenance at the time of the earthquake, the other three were shut down automatically by the emergency system. The shutdown for inspection proved that better earthquake-detection systems were needed before operations could resume. The mayor of Kashiwazaki ordered all seven reactors closed indefinitely (Christoffels, 2007). Taking the plant offline required just two years, 'but the myth of absolute safety remained practically unquestioned' (Lippert, 2012a). The public confidence in nuclear power further deteriorated, however, as the country's nuclear regulators knowingly allowed the unsafe situation of many nuclear plants to persist.

In addition to numerous smaller nuclear accidents since the mid-1990s until the Fukushima disaster, Tokyo's nuclear expansion plans were already in doubt due to the resistance of some of the regions. Although a strong antinuclear movement and a powerful 'Green Party' did not exist in Japan until 2011, compared with Germany and other European countries the opposition against new nuclear plants reflected an increasing NIMBY-attitude.[2] This had already made nuclear power a 'wild card' in regard to the ambitious energy plans of the Japanese governments and the 'nuclear village' – the unofficial cozy relationship and network (known in Japan as 'amakudari') between pro-nuclear politicians, bureaucrats, nuclear operators, electricity companies, large industrial firms and journalists and scientists (Aldrich, 2011; Umbach, 2006, pp. 45–51).

The state regulatory committee responsible for an independent review of the operating nuclear plants, for instance, had not conducted a single inspection for more than seven years. The independence of Japan's regulatory watchdog had already been in question before 2011, and was in reality a member of the 'nuclear power village'.

Before 2011 U.S. regulators had offered the criticism that many safety improvements existing in other nuclear power plants internationally had not been introduced in Japan. Heeding this complaint could have saved more of the Fukushima reactors as well as many lives. In 2008, the U.S. ambassador in Tokyo sent a classified cable to Washington and warned that the 'compartmentalization and risk aversion within the [Japanese] bureaucracy' as part of its long-stagnant political landscape could increase Japan's vulnerability and its official and logistical unpreparedness for earthquakes and even cyber-attacks (Fackler, 2011a).

Instead of training its employees in practical crisis- and disaster-management skills, before 2011 TEPCO and other plant operators had only conducted obligatory safety drills as a mere formality. Moreover, Japan lacked the basic hardware to respond to any nuclear crisis, including emergency robots. It even had to import a 203-foot-long water pump to inject 90 tons of fresh water into the No. 1 reactor building (*NYT*, 2011b).

In one of the most critical situations of the Fukushima crisis, Prime Minister Naoto Kan (June–September 2011) took action by physically stepping into TEPCO's headquarters after the company wanted to evacuate its staff from the heavily damaged plant. He demanded that the staff remain and threatened the managers that he would put his own life in danger by going to the plant himself in order to prevent the disaster from worsening. Later, he was criticized for distracting the plant's staff in their efforts to save the overheated reactors. But Kan explained that he needed to get an independent assessment directly from the plant manager because he felt he had not been sufficiently informed by the TEPCO officials in Tokyo (*NYT*, 2012b). In his view, he was fumbling in the dark as he did not get sufficient and accurate information and instead received downright confusing risk analyzes from the chief nuclear regulator.

Kan distrusted the pro-nuclear camp and bureaucrats. He had built his career as a crusader against inept and corrupt bureaucracy and was highly suspicious of the collusive ties between Japan's industry and political bureaucracy. As a result, he trusted only a small circle of close advisers and refrained from using the crisis management system, created in 1986. But his small group of trusted advisers had little experience of handling such a large crisis. This prevented Kan from fully grasping the severity of the catastrophe. It prevented a timely response and did not even ensure that he was aware of all the resources that Japan has available to the prime minister and the government (*NYT*, 2011d).

An official 641-page Japanese government report of July 2012, based on 900 hours of hearings and interviews with 1,267 people, criticized amid growing anti-nuclear protests that the preparations by TEPCO for natural disasters were insufficient, the response to the crisis 'inadequate' and the communication between TEPCO, the bureaucrats and the prime minister's office insufficient. It even accused TEPCO that more than a year after the Fukushima disaster it still did not show any real interest in clearly investigating the causes of the accident at the plant. In addition, a parliamentary investigation report criticized Prime Minister Naoto Kan for meddling, which confused the initial response, and it also blamed him for the breakdown in communications between TEPCO and the prime minister's office. But overall, the Kan administration's response to the triple disaster was much better than, for instance, the Bush administration's efforts in coping with Hurricane Katrina (Curtis, 2011).

Together with another review of the nuclear disaster by a separate committee of an independent foundation concluded in February 2012, all three reports have been highly critical with respect to preventing, preparing and managing the crisis, and they all came to similar conclusions (*FT*, 2012a). The very existence of an independent investigation commission can be seen as a break with precedent in Japan, following similar patterns in the United States and Europe after major accidents, failures and natural disasters.

But whilst these reports harshly criticized individuals and organizations, no one had specifically been blamed due to the particular cultural dimension of 'made in Japan'. The parliamentary report cited the following 'Ingrained conventions of the Japanese culture': 'Our reflexive obedience; our reluctance to question authority; our devotion to sticking with the program; our groupism; and our insularity. Had other Japanese been in the shoes of those who bear responsibility for this accident, the result may well have been the same (cited *NYT*, 2012c; Curtis, 2012).'

Well-known Japanese foreign and security policy expert Yoichi Funabashi explained the 'made in Japan'-problem with respect to safety and security with a 'culture of overconfidence and arrogance' as well as the secrecy of its pre-disaster nuclear regulation system as the result of Japan's 'Galapagos-syndrome' – a condition describing the phenomenon of a society evolving in isolation from the rest of the world (Funabashi and Kitazawa, 2012). There have also been collusive ties between the industry and academics, whereas critical academics face discrimination, as in not getting funding for research projects.

The identified causes of the nuclear disaster have been confirmed by a report of the IAEA, which also highlighted the unpreparedness and the failure to implement adequate protection (like varied and redundant backup systems at the plants) to withstand high waves of large tsunamis (Fackler, 2011b). Shortly after the catastrophe, Japan quietly decided to rebuild its controversial seawalls as part of its national reconstruction programme for the tsunami-hidden region, at a cost of $650 million (Onishi, 2011).

Does nuclear power have a future in Japan?

In 2010, Japan's government released a new updated Strategic Energy Plan (SEP), which called for at least 12 newly constructed reactors by 2020 and 14 new nuclear units by 2030 alongside an increase in the share of renewable energy sources (RES) and for subsidizing the deployment of low-carbon technologies in order to reduce greenhouse gas GHG emissions. In January 2011, despite safety warnings, Japanese government regulators approved a 10-year extension programme for the oldest of the six reactors at the power station of the Fukushima Daiichi plant. But when confronted with the nuclear catastrophe on 11 March that year, TEPCO had to admit that it had failed to control 33 pieces of equipment related to the cooling systems and diesel generators. Regulators criticized the inadequate maintenance management and the insufficient quality of inspection. Nonetheless, nuclear plant operators had lobbied to extend their reactor's use beyond the usual 40-year operational limit. Already before 2011, critics had warned that not only TEPCO, but the entire system and organization were 'inherently untrustworthy' and flawed (*NYT*, 2011).

By 2012 radiation levels in the destroyed communities near Fukushima Daiichi had fallen by 40 percent. But the cleanup in the form of assisting financially evacuees, decontaminating their abandoned homes and decommissioning the Fukushima plant will cost more than $100 billion and last for another 30–40 years (OECD-NEA, 2012). According to the World Health Organization (WHO), around one third of the plant's workers face increased risk of various forms of cancer and leukemia (*Guardian*, 2013).

The massive earthquake and the giant tsunami happened in a comparatively remote region with a total population of just 8.65 million in 2010 and just 6 percent of the residential housing in Japan and with around 7 percent of the national GDP (2007 figures), but a similar earthquake hitting the industrial heart of Japan – with the highly industrialized city areas of Shizuoka, Nagoya, Osaka, Kobe and Hiroshima – would damage an area accounting for a total of 40 percent of Japan's GDP, or the total GDP of Great Britain and France together. Cascading power disruption could hit some 27 million people, even without secondary effects such as nuclear disasters and radioactive contamination (Lippert, 2013a). The greater Tokyo region alone represents no less than one third of the nation's economic output.

Moreover, the shortfall of electricity imports from the north cannot really be replaced by imports from other regions. Due to a historical rivalry between Tokyo and Osaka, different grid systems have been created, with different frequencies (60Hz for Osaka and 50Hz for Tokyo), which would make any power-sharing inefficient. Furthermore, transfer stations have only limited capacities.

While the country previously had enjoyed an efficient, stable and safe daily electricity supply and did not have to cope with major electricity blackouts, one year after Fukushima, electricity cutoffs would rather become the rule, particularly during hot summers. This prompted the government on 1 July 2012 to restart two nuclear reactors to guarantee a base-load supply just two months after all nuclear reactors had been shut down.

Prime Minister Kan's slow nuclear phase-out policy and the re-examination of Japan's traditional nuclear-centred energy policies were fully in line with public opinion, but he failed to coordinate his own personal convictions with those of his ministers for economics and fiscal policy, Kaoru Yosano, and for economics and industry, Banri Kaieda.

For Kan's successor as prime minister, Yoshihiko Noda (September 2011–December 2012), it was equally difficult to find the right balance between economic and political considerations and to return to the energy policy status quo ante. In October 2011, the Noda administration began to discuss a new energy policy and the future of nuclear power alongside new safety measures at the existing nuclear plants. At that time, only 10 of the 54 Japanese reactors were generating electricity. The government was considering three options: (a) to reduce nuclear power to zero as soon as possible; (b) aiming at a 15 percent share by 2030, and (c) seeking a 20–25 percent share by the same date. Thus, even the government was no longer considering a full restart of all remaining 50 nuclear reactors and giving nuclear power the main role in its future energy mix and energy security strategy.

Meanwhile, the already troubled Monju prototype fast-breeder reactor project, using a uranium and plutonium mix known as MOX fuel, has been reactivated, but is facing further rising costs of up to around a thousand times greater than the current power-generation cost of nuclear power plants. The reports have further raised mistrust and stimulated anti-nuclear protests, whilst the Japan Atomic Energy Commission has been unwilling to discuss the additional costs of the Monju project or to consider ending it. Officially, the Monju fast-breeder project will remain a research programme.

On September 7, 2012, a working group of Democratic Party of Japan (DPJ) heavyweights endorsed Japan's nuclear phase-out by 2030. On September, 14, after the decision had been approved by a subcommittee of the cabinet and by Prime Minister Noda, the policy was replaced again by a compromise, leaving the country's future energy policies in a major state of confusion. The plan was threefold: (a) no new nuclear plants will be built; (b) no nuclear plants will be extended beyond the 40-year age limit, namely 2040 at the latest, and (c) no shut-downs will be restarted unless the new Nuclear Regulatory Authority (NRA) can certify their safety. The government also promised a review of energy policy every year through 2015 and every three years thereafter (Lippert, 2012b). If existing plants are restarted and all are shut down after reaching their 40-year age limit, nuclear power would still supply around 15 percent of the country's electricity by 2030 (Katz, 2012). Thus the Noda government was promoting a nuclear phase-out policy by not building new reactors, but did not want to reduce the operational life of Japan's nuclear reactors.

A few weeks later, three approved but unfinished nuclear reactors were excluded from the central provision of the phase-out policy, under which no new nuclear plants will be built. Japan's Noda government had obviously played for time and had postponed a final decision. While supporters of that government decision have argued that the new partially built plants will contain the latest safety technologies and that decommissioning would mean writing off tens of billions of yen already invested in construction, critics have questioned the underlying economic rationale without knowing exactly what kind of insurance system will be implemented and whether sufficient trust will emerge as a new safety culture, safety upgrades will be costly.

At the beginning of May 2012, Japan had no nuclear power plants in operation and became a nuclear-free country for the first time in more than 40 years. From then on, it was clear for Japanese economists and energy experts, as well as business groups, that if Tokyo keeps its reactors offline, the country faces significant negative short-term economic consequences, such as higher electricity prices for industry as well as for private consumers, and that it would struggle with electricity shortages, particularly during the summertime, and imports of fossil fuels from unstable energy-exporting countries would increase even further, leading to increasing GHG emissions as well. To date, nuclear power is seen as the only proven energy source of low-emissions 'base-load' power that guarantees electricity supplies around the clock independently of weather conditions and of day and night. Accordingly, many experts still see the resumption of nuclear power as a crucial precondition to avoiding further economic damage and to stimulate an economic revival. Especially in the summertime, Japan has to cope with a nation-wide supply gap estimated at around 16,560 MW – about 10 percent of peak-hour demand.

Furthermore, some regions have been heavily dependent on jobs and subsidies from Tokyo and, therefore, are in favor of a restart of nuclear power plants (Dusinberre, 2011). After switching off the last nuclear power plant, some regions became so concerned with electricity shortages that the rural town council of Oi in the western prefecture of Fukui approved the restart of two reactors. And in Mihama city 45 percent of the municipal budget stems from nuclear-related taxes and subsidies.

International experts and organizations such as the World Economic Forum (WEF) have also warned that Japan risks jeopardizing its energy security and economic situation. Like other countries, Japan needs to deal with difficult and contradicting tradeoffs and with difficult choices to balance the three objectives of the energy triangle, namely: (a) to strengthen its access to basic energy resources at (b) affordable prices and for a (c) sustainable climate-friendly transition path. The WEF also warned that a major strategic shift towards renewables would require a transition on a scale never seen before and necessitate financial investments on an unknown scale (WEF, 2012). Similar warnings and recommendations have been voiced by the Organization for Economic Cooperation and Development (OECD) (Byrne, 2012a).

But a restart of the nuclear reactors has also been opposed by many local and provincial governments. The best-known is the young Osaka mayor, Toru Hashimoto, Japan's new rising political star, who has given the new, more powerful, anti-nuclear movement and a public holding deep-seated suspicions, an influential voice and a face. In addition, previous prime minister, Naoto Kan, criticized nuclear power as too dangerous and accused the powerful 'nuclear village' of pushing Japan back toward nuclear. In order to break the grip of the 'nuclear village', he advocated the forming of a new genuinely independent regulatory agency, which should also include American and European experts (*NYT*, 2012b).

Throughout 2012, opinion polls highlighted the fact that the majority of Japanese respondents trust neither nuclear power itself nor the people in charge and in control of it. Even an opinion poll of 400 major Japanese companies revealed that at least 20 percent of these favored the complete abolishment of nuclear power – something unthinkable before the Fukushima disaster (Katz, 2012).

The new government party, the Liberal Democratic Party (LDP), announced shortly after its return to power in December 2012 that reactors would be restarted after having passed a series of new safety tests. However, the 'cold shutdown' of Fukushima, returning the plant to an apparently more-or-less stable situation, not causing any further problems such as leaking contaminated water, soon caused new problems and dangers. A power outage in March 2013, caused officially by a faulty switchboard, left four underground pools that store the plant's 8,800 highly radioactive fuel rods without fresh cooling water for several hours. This caused another IAEA investigation, which highlighted that the pipes used to transfer water to safer storage containers are leaking, and that the quantity of contaminated water has become a crisis by itself (*NYT*, 2013a). The structural integrity of Unit 4 of the Fukushima Daiichi plant has already been deemed 'precarious', which could result in an 'even greater release of radiation than the initial accident', as visiting U.S. senator Ron Wyden warned in letters to U.S. secretary of state, Hillary Clinton, and the Japanese ambassador to the United States (*FT*, 2013a).

It remains to be seen whether the new government has sufficient political willpower and skills to assume a pro-active leadership role in its energy politics, as in the 1970s when the government introduced fundamental economic and energy policy efforts for increasing energy conservation and enhancing energy efficiency. These effort made Japan one of the leading nations in energy efficiency and environmental technologies, far more innovative and competitive than other industrialized countries (Smith, 2011).

Under the new Abe government since December 2012, the Japanese electric utilities have requested to restart 10 nuclear reactors under new safety rules to be introduced by the newly established Nuclear Regulation Authority (NRA). But, in January 2013, the NRA released a list of new safety regulations. Prime Minister Shinzou Abe promised to enforce the new safety standards 'without compromise', though reportedly none of Japan's 16 undamaged commercial nuclear plants would pass the new standards (*NYT*, 2013c). Those initial safety upgrades are estimated to exceed $10 billion in addition to the cost of decommissioning aging reactors and of waste clean-up. It could make Japanese nuclear reactors another financial burden. Given the technical and political complexities, most experts do not expect any of the modernized reactors to be operative before 2014. But, even then, most observers assume that only three to five reactors will restart.

While international energy experts understand full well that Japan will not phase-out all of its nuclear reactors in the short- and medium-term, the recent decision of the Abe government to revive the controversial Rokkasho nuclear plant project, which enables Japanese power companies to reprocess spent nuclear fuel domestically in order to increase Japan's energy self-sufficiency and independence, has again raised concerns that the country will not give up on a future nuclear weapons capability, as the plant is capable of producing nine tonnes of weapons-grade plutonium from Japan's unusually huge reserve (37 tonnes) of non-weapons grade plutonium – sufficient to build up to 5,000 nuclear warheads (Lippert, 2013). This controversial plutonium reserve has increased from 7 tonnes in 1993 and could officially be used when the originally planned network of next-generation reactors are able to employ fuel that includes plutonium for reuse in a self-contained cycle, using up most of the plutonium reserve by 2030.

Short-term impacts: rising LNG imports and supply risks

Even before Fukushima, Japan, as the third-largest consumer and importer of oil (after the United States and China) consumed 4.5 million barrels per day (mb/d) and imported 4.3 mb/d. 87 percent of Japanese crude oil imports are supplied by the politically unstable Middle East, with Saudi Arabia the largest source of imports. In order to guard against supply disruptions, at the end of 2011 Japan had stored 589 million barrels, 55 percent as governmental stocks and 45 percent as commercial stocks. Since 2000, Japan has decreased its oil dependency by almost 20 percent (EIA, 2012), through energy-efficiency measures and the diversification of its energy mix (including nuclear power viewed as a domestic source), making Japan less dependent on highly insecure oil supplies from the politically unstable Middle East.

As part of its 2006 energy security strategy, the government's objective was to further decrease its oil consumption and by 2030 to import 40 percent of the country's total crude oil from Japanese-owned concessions belonging to the state-run Japan Oil, Gas and Metals National Corporation (JOGMEC), up from 19 percent in 2012. However, in order to compensate for the loss of almost all nuclear power, Japan was forced to import 30,000 b/d in 2011, and another estimated 80,000 b/d in 2012. The cost of imported fossil fuels rose from 1 percent of Japan's GDP in 1998 to almost 5 percent few months after the Fukushima event (*NYT*, 2011c).

The Japanese government has encouraged Japanese energy companies to increase their involvement in oil and gas projects outside Japan, from 20 percent to 40 percent of world LNG projects over the next 20 years (*Natural Gas Daily*, 2011). With the declared nuclear phase-out policy, and as long as renewables cannot guarantee a base-load supply, the loss of Japan's nuclear reactor capabilities will be replaced primarily by fossil-fuel imports.

Japan's oil-supply situation became even more challenging when the country was forced to decrease its imports from Iran as the result of Teheran's unwillingness to cooperate with the IAEA over its perceived nuclear weapons ambitions and as a result of U.S.-led international sanctions. This further complicated Japan's decades-long efforts to diversify its crude oil imports.

Given its limited, and declining, proven natural-gas reserves of 738 billion cubic feet (bcf) as of January 2012, Japan was already before 2011 the world's largest importer of LNG, with about 33 percent of the global market (EIA, 2012). Natural gas comprised 27 percent of the country's total power supply, second only to coal with 43 percent.

While coal was not used as the primary substitute for the loss of nuclear power supply and even experienced a decline in consumption in 2011, Japan's LNG imports rose by 12 percent in 2012 to 3.8 trillion cubic feet (tcf) or 87 mt (78.5 mt in 2011, and 70 mt in 2010) with a far more diversified supply source than in its oil-import portfolio. By the end of 2013, LNG import demand may rise further, to almost 90 mt. If nuclear reactors restart in 2014, the LNG import demand may decrease by 5 mt per year in a best-case scenario.

But LNG import prices rose by 38 percent in 2011, compared to 2010. Between 2010 and 2012, total LNG costs surged from ¥3.5 trillion ($42 billion) to ¥6.5 trillion ($78 billion). This resulted in a record trade deficit of $74 billion in 2012. Trade Minister Yukio Edano warned that Japan is experiencing an unprecedented 'outflow of national wealth' (Bogle, 2012). If most of Japan's nuclear reactors are not restarted, by 2030 Japan's LNG consumption may even double (Byrne, 2012a). But Japan also has to cope with growing LNG prices in the light of the country's gigantic public debt of approximately 200 percent of GDP and rising electricity prices, all undermining its economic competitiveness.

In addition to its more pro-active energy foreign policies for securing and diversifying its oil and LNG imports, Japan has also become interested in U.S. shale gas and the option of importing stable and more inexpensive LNG from the United States. The Japanese government, in February 2013, offered the United States project financing and loan guarantees for its planned LNG-export terminals as well as credit guarantees to fund investments by Japanese companies in U.S. shale-gas projects. Mitsui and Mitsubishi are developing and building Sempra Energy's $6 billion Cameron LNG-liquefaction plant in Louisiana in order to diversify Japan's LNG imports.

At the same time, Japanese utilities have become increasingly reluctant to commit themselves to any new oil-indexed LNG supplies. Japan has also shown great interest in European gas-market price developments by giving up the oil-indexed gas price, which has been a feature of the LNG industry for decades. Given its LNG demand growth, Japan has become the primary factor driving the spot-LNG market in Asia. Tokyo hopes to import LNG on the basis of Henry Hub prices from the United States from 2015 onwards. This will eventually account for 10 percent of the country's total imports. But Japan faces strong competition from Asian competitors (that is, China), as Asian LNG demand is expected to account for 61 percent of global LNG-growth until 2030.

Despite diversification efforts, Japan's LNG supplies from the Middle East rose by 28.6 percent between April 2012 and April 2013. At present, Australia has become the largest LNG supplier for Japan, ahead of Qatar. But Australia's LNG costs are very high and will not substantially drop, as new LNG projects will not lead to reduced labor and construction costs. As a result, with the emergence of U.S. LNG exports, Australia is losing its competitiveness. Currently, only 10 percent of Japan's LNG imports come from Africa, with Nigeria accounting for more than 50 percent. Russia is another potential strategic supplier, as Moscow seeks to reduce its dependence on the stagnating, or even decreasing, European gas market. But failing political trust and high Russian gas prices are hindering Japan from creating a comprehensive gas partnership with Russia.

At the same time, gas is facing tough competition as the base-load fuel for power-generation with coal, which is much cheaper. Whereas the average LNG import price in Japan was $16.6 per million British thermal units (mmBtu), the average price for thermal coal was $4.7 per mm Btu. Thus, Japan will not only remain the second-largest importer of coal worldwide, but will also use coal as the primary base-load fuel in the years to come (Kumar, 2013).

Perspectives for expanding the potential of renewable energy and liberalizing energy markets

As the result of the Fukushima disaster and the loss of public trust in nuclear power, the Noda administration revised its energy policy to promote a greater use of renewable energy sources such as solar, wind, geothermal, hydropower and biomass.

Until 2004, Japan was the world leader in the installation of solar photovoltaic cells, with companies like Sharp and Sanyo among the world's largest manufacturers of solar panels. But, in the following years, Germany and Spain surpassed Japan in terms of installations of solar panels due to their high consumer subsidies. While Japan is still the third-largest solar energy market, wind power has never been of similar importance as in Germany and Europe, because in general Japan has not been seen as suited for wind power with the exception of the northern regions. But the country has the world's third-largest potential for geothermal power and the sixth-highest for wave power (Ministry of the Environment, 2011). Moreover, Japan is internationally still a very strong innovator in energy and related technologies such as smart grids and smart metering, despite the fact that more than 50 percent of Japan's energy research and development budget is still devoted to nuclear. In 2012 Japan accounted for 45 percent of worldwide patent applications in smart-grid technologies. Among individual companies applying for patents, the top 10 included no fewer than eight Japanese firms (DeWit, 2013).

Before Fukushima, renewables made up just 3 percent of power-generating capacity (a level practically unchanged since 1973), much lower than the hydroelectric share, which stood at 7 percent. Due to its successful energy-efficiency programmes and a declining population, Japan has one of the lowest electricity-demand growth rates in the Asia-Pacific, projected to increase at an average of just 0.7 percent until 2018 (EIA, 2012).

Following the Fukushima crisis, the government implemented a power-restraint strategy for consumers in the disaster-affected regions throughout 2011, aiming at a 15 percent power reduction for all consumers.

At the end of September 2012, the DPJ's new energy policy presumed that renewables will generate 20 percent of electricity within 10 years and 30–35 percent by 2035. The government hoped to achieve this goal by new feed-in tariffs for solar, wind power, biomass and other renewable energy sources, at an estimated cost of ¥50 trillion ($652 billion). The government's 'Sunrise Project' aimed to lower prices for solar panels by a third by 2020 and then to cut prices in half by 2030. The programme seeks to install solar panels on 10 million Japanese homes by 2020, with renewable energy then providing 20 percent of the country's electricity. In 2011, solar module prices had fallen by 40 percent since 2010. In the first quarter of 2013, Japan's solar capacity was boosted by 270 percent due to the country's new generous feed-in tariff for RES – more than twice that of China and Germany. At the end of this year, Japan hopes to have installed new solar PV capacity equal to the capacity of seven nuclear reactors.

The government also seeks to expand the use of geothermal energy, as the country is geographically located along the 'Pacific Ring of Fire', an arc of seismic activity that constitutes one of the world's largest energy reserves. But, worldwide, less than 4 percent of the global resources have been used because of high upfront costs and investment risks.

Even before Fukushima, Japanese experts were questioning whether or not Japan would be able to achieve its target of a 25 percent reduction in GHG emissions by 2020. According to an Environment Ministry Council, it might be able to decrease its GHG emissions only by up to 19 percent from 1990 levels – and even this rests on the assumption that (a) the share of nuclear power generation is maintained at 35 percent in 2035 and (b) that it purchases emissions quotas from overseas. Its various scenarios highlighted the challenge that the more Japan reduces nuclear power in its energy mix, the less will be the cuts to GHG emissions by 2020.

If Japan gives up nuclear power generation, its GHG emissions reductions would reach 11 percent at most, instead of the pursued 25 percent (Yomiuiri Shimbun, 2012). When Prime Minister Yukio Hatoyama (September 2009–June 2010) at the September 2009 UN Climate Change Summit announced that CO_2 emissions should be reduced by 25 percent compared to 1990 levels, it was based on the condition that Japan would build nine new nuclear reactors and operate them at a rate of 80 percent or higher. Thus, it is hardly surprising that most Japanese energy experts warned the government not to abandon nuclear because doing so would threaten Japan's global-warming and energy security commitments as well as undermine its population's quality of life and the country's economic development (Endo, 2011). Meanwhile, the Japanese government has not only announced that its pledges to the 2010 UN climate change conference are no longer viable, it has also decided to no longer participate in the Kyoto Protocol (Kurokawa, 2013).

Beyond the expansion of renewables, Japan's future energy security also depends on fundamental reforms to its energy sector, such as the break-up of its electric power monopolies, separating generation from transmission and letting in new entrants so as to raise energy efficiency and reduce transformation costs over the next years and decades. Up to now, Japan has been 'balkanized' into 10 regional and monopolized utilities which have very little interaction with one another as part of the (united) power market.

In April 2013, Japan's new Abe government (December 2012) took the first steps to initiate reforms in such a direction and to foster competition by obliging utilities to separate power generation and distribution into separate businesses. If fully implemented, it will liberalize power sales and generation by around 2016 and fully split the power generation and transmission sectors by 2018–20 (*NYT*, 2013b). The need to introduce smart-grid and smart-metering technologies alongside the expansion of RES offers another opportunity to overcome the 'balkanization' of Japan's power sector and strengthen the country's energy security.

But the Japanese government also has major security concerns with its rising dependence on RES and the related import from China of critical raw materials (that is, rare earths) for its RES and other green technologies, as China's 2010 rare-earth embargo of Japan highlighted (Umbach, 2012, 2013a).

Summary and strategic perspectives

While Japan has also decided to phase-out nuclear beyond 2030, it is still in the process of defining a sustainable comprehensive energy policy based on the three objectives of the energy triad, namely to enhance supply security, to mitigate environmental/climate change and to preserve or increase its economic competitiveness. In this regard, Germany's June 2011 nuclear phase-out decision and its – compared to Japan – much more advanced comprehensive energy transformation ('Energiewende') can offer important lessons for Japan's future energy policies and its own 'Energiewende'. The German example has highlighted major questions of feasibility, costs and implications, even for neighboring countries. With the nuclear phase-out decision, Germany has to rely even more than in its past on electricity imports from neighboring countries, often running on old, but reliable coal, gas and even more unsafe nuclear plants for years to come, as the EU's nuclear stress tests results have highlighted.

But in comparison with Germany's energy policies, Japan is geographically an island and cannot rely on neighboring countries supplying electricity or on being connected to an international grid. It is forced to maintain an independent national energy system, exacerbating widespread feelings of insularity, isolation and the need to pursue unilateral and more costly strategies to solve its energy problems. In light of Germany's recent experiences with its 'Energiewende' and the transformation of its entire energy sector, the WEF has warned that any wide-ranging strategic shifts in energy policies need to avoid hasty and short-sighted decisions. Thus, Germany did not balance its competing imperatives and take into account the effects of its decisions across the entire value chain, leading to unintended consequences and cascading effects. Germany's immediate nuclear phase, alongside a rapid expansion of renewables, was intended (and publicly justified) to produce long-term environmental and economic benefits. But the hurried decisions have resulted in rapidly increasing electricity prices, rising carbon emissions (as Germany has to turn to coal and gas to compensate for the loss of nuclear) and unstable electricity supplies (WEF, 2012b; Umbach, 2013b, 2013c).

What the German experience can teach us, with its rapid nuclear phase-out policies, is that the traditional feed-in tariff system only works until the expansion of RES has reached a level of around 20 percent of the energy mix. Then it becomes very costly because the expansion of RES needs a rapid transformation of the entire energy system, with an equal expansion of smart grids and smart-metering technologies as well as of creating expensive capacity markets: fossil-fuel power plants are still needed for base-load stability, but would run only few hours per day, making them commercially unprofitable for private utility companies. Thus, a rapid expansion of RES makes the energy bills for private consumers as well as the industry much more expensive in the short and medium term. Such an underestimation of the financial and economic costs as well as the political problems of the transformation of the entire energy system is now threatening Germany's and Japan's future industrial competitiveness.

Until the Fukushima catastrophe, all Japanese governments wanted nuclear power to have an even larger share of the national energy mix as well as of power generation by 2030. But even before Fukushima, governmental nuclear power expansion plans became the wild card of Japanese energy policy due to NIMBY attitudes from local populations opposing new nuclear power plants and because of numerous smaller nuclear accidents and scandals of mismanagement within the nuclear industry (Umbach, 2006).

Fukushima was ultimately a 'man-made disaster' and 'made in Japan', a result of collusion among TEPCO, regulators and the government, as three Japanese reports investigating the Fukushima disaster concluded.

Maintaining and operating existing nuclear reactors does not contradict the planned expansion of RES. But a more forward-looking energy policy may maintain a better energy security profile and the fulfillment of the GHG emissions goals, and would offer a more realistic and stable, as well as sustainable, path to the next generation of a sustainable energy architecture. Moreover, China's rare-earth embargo in 2010 was a sharp reminder of just how much Tokyo depends on imported industrial materials from its large neighbor, and that its increasing reliance on RES also creates new geopolitical dependencies and vulnerabilities.

From an economic point of view and considering Japan's already-high energy security risk index, Japan needs to restart its newer nuclear power plants as soon as possible. But it cannot do so without the renewed confidence and support of its population, which cannot realistically be achieved in the short term. Even the more nuclear-friendly Abe government cannot return to the status-quo ante of Japan's energy strategy of 2010, which favored an expansion of nuclear in Japan's future energy mix. Given continuing public concerns about the future use of nuclear power in Japan and the pro-RES policies at the local and regional levels in the country, the energy policies of the future already appear to be shifting increasingly from centralized and nuclear power to decentralized and distributed energy generation based on RES, without giving up on nuclear power for the mid-term future. With the exception of the share of nuclear power in Japan's future energy mix, energy policy since Fukushima has revealed incremental rather than revolutionary changes.

Japan's growing dependence on increasing and expensive LNG imports and its steadily rising subsidies for expanding RES also complicates Prime Minister Abe's plan for a strong revival of its long-foundering economy. These problems can be seen in the recent decision by the Abe government to speed up the environmental assessment process for new coal-fired power plants, as its power sector has to struggle with surging energy bills because of the rising oil prices and its rapidly increasing LNG imports as well as rising LNG prices. In 2012, Japan's energy sector recorded $13 billion in annual pre-tax losses as a result of rising imports and fossil fuel prices. Economically, such a development is unsustainable even in the short-term future. While this situation speaks in favor of a restart to at least some of Japan's undamaged nuclear reactors, the introduction of new safety standards makes the prospects for the nuclear sector rather mixed.

Overseas, the Turkish government recently confirmed that the Japanese company, Mitsubishi, and French partner, Areva, will build Turkey's first $20 billion nuclear power station (with four reactors producing 4.5 GW of electricity) on its Black Sea coast. Construction is due to start in 2017. Thus, while prospects for selling Japanese nuclear power-plant technologies abroad appear rather positive, the restart of Japan's nuclear reactors is becoming economically ever more difficult due to the intended liberalization process of the energy sector and because of competition from other energy sources: some RES have seen dramatically decreasing costs (that is, solar power), coal is getting cheaper, and LNG prices might even, in Asia, potentially no longer be oil-indexed. And both the Japanese government and the nuclear industry know that another nuclear accident would mean the immediate and complete end to the civilian use of nuclear power in Japan.

With rising LNG imports based on oil-indexed prices, and confronted with continuing widespread public opposition to nuclear restarts, Japan hopes that cheaper U.S. LNG exports will be available to decrease its import costs. The need for future, even more expensive, LNG imports depends in the next years primarily on how much nuclear-reactor capacity will come back online in 2014 and beyond.

Notes

1. The indexes are based on quantitative analyses. The study by the U.S. Chamber of Commerce and the Institute for 21st Century Energy is based on individual energy security measures, organized in 8 broad categories and uses 28 individual metrics covering a wide range of energy supplies, energy end uses, operations,

and environmental concerns for comparing countries and their energy security over time as well as understanding absolute and relative trends in individual countries. These metrics and the indexes are based on data from the U.S. Energy Information Administration, and also IEA, BP and others (Institute for 21st Century Energy/U.S. Chamber of Commerce, 2012, pp. 73–84).

2. Not In My Back Yard.

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4

The Impact of 3–11 on Japanese Public Opinion and Policy Toward Energy Security

Paul Midford

Introduction

Ever since Japan began industrializing in the late 19th century the country has lacked sufficient energy resources to meet its needs, a situation that continues to this day. Starting in the 1960s, and especially since the oil crises of the 1970s, Tokyo has promoted nuclear power as the primary means for enhancing Japan's energy security, along with efforts to increase energy efficiency. It is widely recognized that the Great East Japan Earthquake of March 11, 2011, which triggered a massive tsunami and a major nuclear accident, undermined this strategy. This in turn provoked a national debate over Japan's energy policy, especially the role of nuclear power versus renewable energy in supplying electricity.

While this characterization is largely accurate, as this chapter will show, Japan's plans for expanding nuclear power generation were already essentially deadlocked before the 3–11 quake and tsunami. Public opinion, both locally, but also increasingly nationally, has been the driver both behind the gradual decline of nuclear expansion in Japan before 3–11, and the more dramatic reversal in policy that ensued following this natural cataclysm.

The rest of this chapter is divided up into seven sections. The next section briefly presents two models of public opinion and its influence on policy, elitist and pluralist, and their applicability to Japanese public opinion. The following section looks at building public support for nuclear power in the 1960s and 1970s, followed by the gradual souring of public opinion toward nuclear power due to the Chernobyl nuclear accident in 1986, and a string of small domestic nuclear accidents, culminating in the 1999 Tokaimura accident, which resulted in a significant radiation release in the surrounding community. The following section looks at public opinion and its impact from the Tokaimura accident up to the eve of the 3–11 quake and tsunami, and shows that continued support for nuclear power coexisted with growing unease about its safety. The section after that looks at how 3–11 caused the public to reevaluate its support for nuclear power and the emergence of a large and stable majority favoring the phase-out of nuclear power over the course of several decades, a majority that nonetheless coexisted with significant support for restarting some of Japan's nuclear power plants in the short term. The following two sections show how a large shift in public opinion influenced energy policy irrespective of a change of government, especially policy regarding nuclear power and renewable energy. Finally, the concluding section evaluates the predictive power of elitist versus pluralist models in explaining the evolution of public opinion and its influence on policy, and looks at how public opinion is likely to influence energy policy with the LDP back in power.

Elitist versus pluralist perspectives on public opinion

The study of public opinion in democracies[1] has been dominated by two competing perspectives: the elitist approach and the pluralist approach. The elitist approach is the most venerable, dating back at least to Walter Lippmann's classic book, *Public Opinion* (Lippmann, 1922). This approach views public opinion as essentially uninformed, unstable, and subject to mood swings. Elitists focus on the views of individual members of the public, and find that these are often characterized by 'non-attitudes' (Converse, 1962). For elitists, following public opinion is dangerous, as the public cannot serve as a wise, coherent, or consistent guide to policy. Elitists, therefore, consider it fortunate that public opinion is also subject to elite molding and, hence, ultimately unable to hold politicians accountable for their decisions (Ginsberg, 1986; Margolis and Mauser, 1989). Normatively, the elitist school argues that politicians should serve as 'guardians' of the public (Sobel, 2001, pp. 11–12).

By contrast, the pluralist approach dates back to the mid-1960s and developed in response to the Vietnam War, when scholars started noticing that public opinion appeared more consistent, and even more coherent, than elite opinion (Jentleson, 1992; Page and Shapiro, 1992). Pluralists thus find collective public opinion stable and coherent. In contrast to elitists, they focus on public opinion as a collective phenomenon, arguing that public opinion is wiser than the sum of its parts. This is because the random errors that individuals make when responding to policy issues, opinion polls, or even at election time, errors that cause them to deviate from their true long-term preferences, cancel out when the views of many individuals are aggregated into the collective that is public opinion. Collective public opinion, they find, is not only apparently wiser, but more stable and coherent than the views of individuals. In the view of pluralists, public opinion is also not easy to mold or to ignore. For this reason public opinion can and does guide policy, especially on large and salient issues. Pluralists thus argue that politicians need to embrace a 'delegate's' model of representation whereby public support is both desirable and necessary for policy success.(Sobel, 2001, pp. 11–12) The causal relationship pluralists see between public attitudes and policy outcomes is depicted in Figure 4.1.

Public opinion, defined here as stable majorities as measured by widely published opinion polls on some issues, such as foreign policy, operates almost exclusively at a national level. On other issues, especially domestic issues, such as energy policy and nuclear power, local public opinion also matters greatly in connection with local facilities. Hence, this chapter examines both levels. Local public opinion regarding local facilities is usually better informed and has stronger stakes and views, both pro and con. National public opinion can have a broadly empowering role for local opinion when the two are aligned. On the other hand, when national public opinion differs local public opinion can face far greater hurdles attempting to have its way.

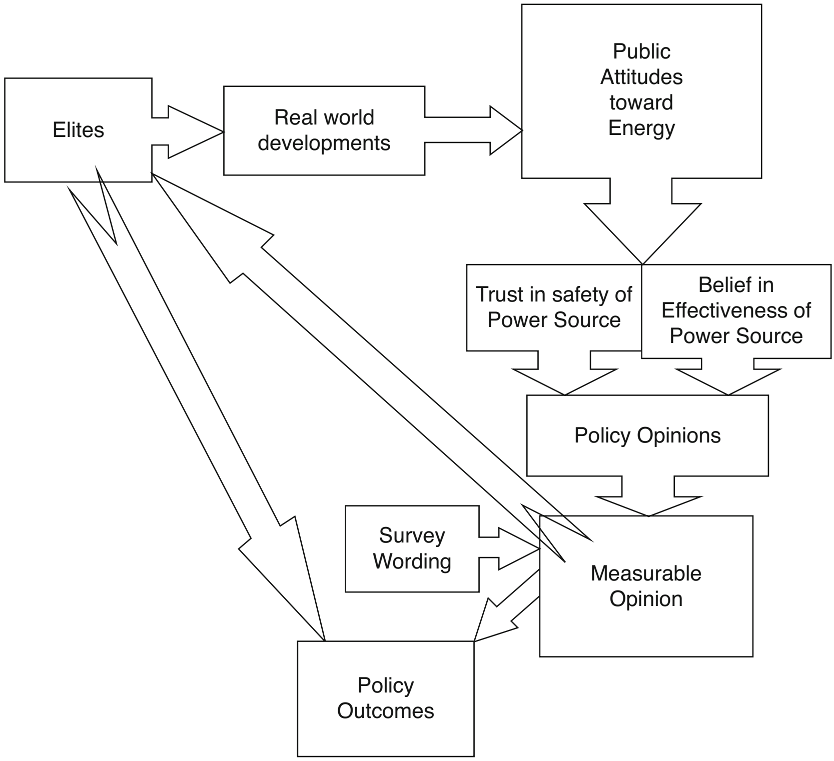

Figure 4.1 The causal connection between public attitudes and policy outcomes

The rise and fall of the Japanese public's embrace of nuclear power

Japan launched its peacetime nuclear power program with the passage of the Basic Atomic Energy Law in 1955 (Baba, 2002, p. 17). Nuclear power, although explicitly limited to peaceful purposes, was nonetheless tied to great-power nationalism. Yasuhiro Nakasone, then a young Diet member and future prime minister, became a leading advocate of Japan's developing nuclear power for peaceful purposes and explicitly linked this with a nationalist agenda. Nakasone would later write that at the time he thought 'nuclear power is the greatest discovery of the 20th century, and if Japan cannot use it for peaceful purposes, the country will forever have to content itself with being a fourth-rate power (*Asahi Shimbun*, 2011).'[2] Japan launched its first experimental reactor in 1963 and turned on its first commercial nuclear plant for generating electricity in 1966 (Aldrich, 2008, p. 125).

Within about a year of the 1973 oil embargo, the Tanaka cabinet passed new laws on electricity production that massively increased subsidies for nuclear power, offering subsidies at double the going rate for thermal plants (Samuels, 2013, p. 114; Suzuki, 2000, p. 6). Japan's nuclear power industry grew rapidly thereafter. Japanese elites even came to see nuclear power as a means for realizing energy independence and, consequently, Japan launched the world's most sustained and ambitious program to develop a closed nuclear fuel cycle.

Already by the 1960s the use of nuclear power for electricity generation enjoyed wide support among the Japanese public, although its lingering association with the atomic bombings in Hiroshima and Nagasaki created some limits to this support. Nonetheless, determined efforts by policymakers, and the demonstration effect of Japan's first nuclear reactors, which operated safely and apparently without problem, caused public support for nuclear power to continue to grow. By 1976, approximately 70 percent of the Japanese public supported building more nuclear power plants, versus only about 10 percent who wanted to maintain the status quo or stop building plants, and about 20 percent who were unsure.[3] In other words, the Japanese public became one of the most pro-nuclear publics in the world.

Nonetheless, already in the 1960s, local opposition to nuclear plants began to materialize, and from the 1970s this was supported by national anti-nuclear activists who, in turn, were supported by opposition parties on the left, most notably the Socialist and Communist parties. Nonetheless, the effectiveness of these anti-nuclear movements was limited by expanding government subsidies, visits by experts and high ranking officials to nuclear facilities, trips for students and other groups to free nuclear-power museums, advertising, examples of what Daniel Aldrich calls 'soft social control' tools (Aldrich, 2008, pp. 64–66, 137) and above all by continued and overwhelming public support for nuclear power nationally, which gave nuclear power expansion legitimacy and stymied the efforts of opponents.

Nonetheless, from the end of the 1970s the public gradually began to sour on nuclear power. The first significant blow to public support came from the Three-Mile Island nuclear accident in the United States in 1979. However, it was the far more serious Chernobyl nuclear accident of 1986 that sparked the first politically significant national, as well as local, public opposition to nuclear power as concerns about its safety mounted.

After Chernobyl

What impact did increasing public concern about the safety of nuclear power have on policy? The implications can be seen in Figures 4.2 and 4.3, which track the increase of nuclear power since 1981, both in terms of total generation and as a share of total electricity generation. What both figures show is that, despite the Three Mile Island accident in 1979, growth in nuclear power, both in terms of electricity generated and even as a percentage of total generation, continued to grow robustly, with generation doubling between 1981 and 1986. Strikingly, however, in 1987 and 1988 there was a noticeable dip in generation, a dip that followed the Chernobyl accident and appears to reflect the influence of that accident on Japanese public opinion, and the public's influence, in turn, on policy and even on electricity generation. The building of new plants slowed, and utilization rates at existing plants fell as electric power companies and the government had to respond to public concerns with additional safety measures.[4]

This post-Chernobyl dip ended in 1989 and nuclear-power generation resumed its upward trend, growing from approximately 23 percent to 32 percent of all electricity generation by 1998. Nonetheless, growing local and public opposition was beginning to take its toll on nuclear expansion.

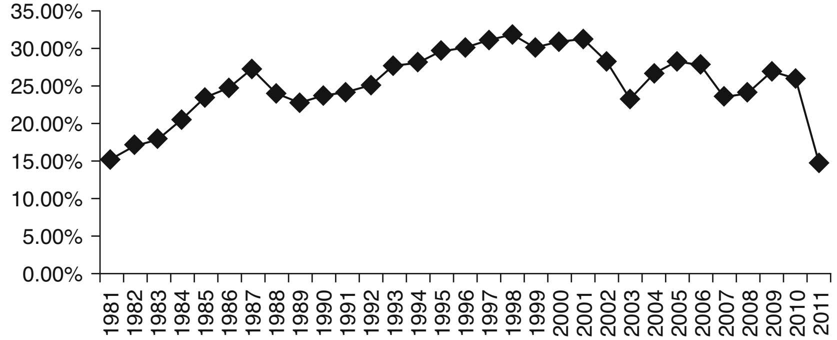

Figure 4.2 Nuclear power as a percentage of electricity generation

Source: U.S. Energy Information Agency (2013).

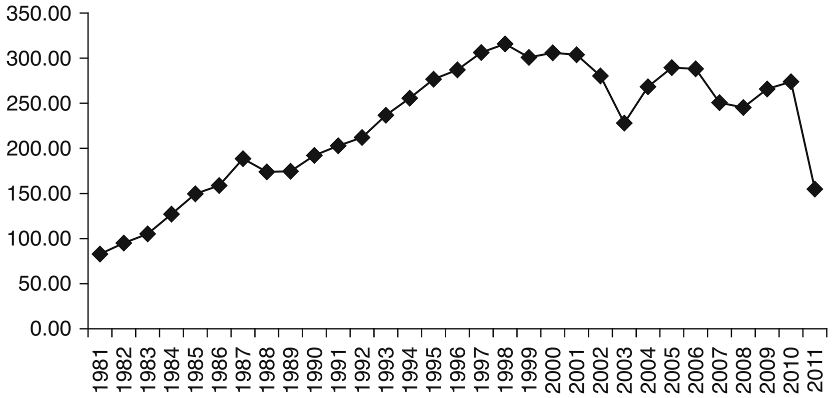

Figure 4.3 Nuclear generation in billions of kilowatt hours
Source: U.S. Energy Information Agency (2013).

As one TEPCO official put it, 'The days when communities invited us to build nuclear power plants to help combat the effects of depopulation are gone. We must offer something useful (*Nikkei Weekly*, October 5, 1992, as cited by Aldrich, 2008, p. 141)'. 'Something useful' almost always took the form of ever-escalating subsidies to obtain 'local buy-in'.

A major coolant leak at the Monju fast-breeder reactor on the west coast of Japan in December 1995, and a subsequent effort to cover up this accident (including with doctored videotape), created a strong public backlash and a movement to close the plant and Japan's fast-breeder program permanently, so much so that the Monju reactor never fully reopened (Aldrich, 2008, p. 139; Samuels, 2013, p. 113; Terazono 1996a, b). This accident also represented an important turning point in two respects: first, for the first time public opinion effectively closed a plant, and second, it ushered in a new period that showed the limits of even massive subsidies, as communities began to turn down reactors anyway.

The clearest indicator of the limits of massive subsidies and the growing strength of anti-nuclear public opinion came a few months after the 1995 Monju accident, when citizens in the small town of Maki-machi in Niigata prefecture brought about the first successful citizen-initiated referendum on hosting a nuclear power plant (Hasegawa, 2004, p. 148).[5] Nearly 61 percent of Maki village residents voted against the plan for a nuclear plant. Maki's mayor, who had been elected shortly after the Monju incident on a promise to hold this referendum, honored the referendum's verdict by selling the remaining land needed to anti-nuclear activists, effectively quashing the plant (Hasegawa, 2004, pp. 148, 153–5; Samuels, 2013, p. 115; Suzuki, 2000, p. 12; Terazono, 1996c).

Tokaimura and after: an increasingly ambivalent public and nuclear stagnation

A far more serious nuclear incident occurred in 1999 in Tokaimura, the first town to host a nuclear power plant. A 24-hour nuclear criticality accident occurred at a uranium fuel processing plant as a result of inadequate training and human error. As a consequence, there was a significant release of radiation into the local environment, and two plant workers died after exposure to massive levels of radiation – the first fatalities due to radiation exposure in the history of Japan's nuclear power industry. Before this accident approximately two-thirds of Tokaimura residents regarded nuclear power as 'safe' or 'fairly safe', but following the accident only 15 percent felt so (BBC, 2000; Suzuki, 2000, pp. 24, 29; Samuels, 2013, p. 113). After the Tokaimura accident the expansion of nuclear power generation ground to a halt, as indicated in Figures 4.2 and 4.3.[6]

Although a majority of Japanese continued to support reliance on nuclear power, growing safety concerns, revelations about repeated cover-ups of (albeit mostly small) nuclear-plant accidents by electric power companies and a resurgence in local opposition stymied further growth in nuclear power during the 12 years separating the Tokaimura accident from the Fukushima-Daiichi nuclear accident following 3–11. Public support for unconditionally building nuclear power plants almost vanished, while those conditionally in favor of building new plants also declined, from approximately 46 percent in September 1990 to 38.8 percent in November

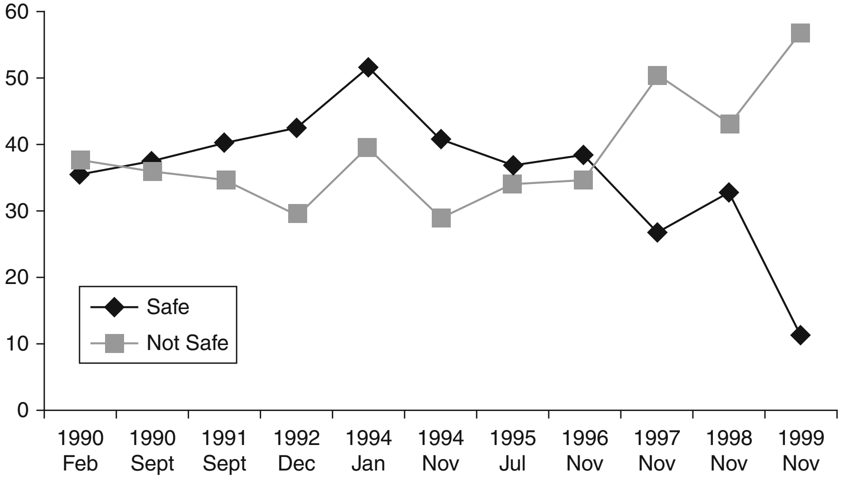

Figure 4.4 Public views on the safety of nuclear power

Source: Naikakufu (1999).

1999. Meanwhile, those calling for maintaining the status quo declined from 17.9 percent to 14.8 percent, and those who favored reducing or eliminating nuclear power increased from 26 percent in 1990 to 27.8 percent in 1999. Figure 4.4 shows that while public confidence in the safety of nuclear power was shaken in the aftermath of the late 1995 Monju nuclear accident and cover-up, it was shattered by the Tokaimura accident (Naikakufu, 1999). This growth in safety concerns helps to explain the stagnation in nuclear generation of electricity that we see from the Tokaimura accident up to 3–11.

In the post-Tokaimura public-opinion environment, long-standing nuclear plant plans that had received central government support began to be abandoned. Most notably, the Ashihama plant, scheduled to be built on the Ise peninsula in Mie Prefecture, a plant initially approved in 1963, was cancelled by the prefectural governor six months after the 1999 Tokaimura accident, a delayed response to opposition from the local mayor and a large petition opposing the plant that dated back to 1996 (Aldrich, 2008, p. 141; BBC, 2000).

In response to these incidents and falling public support, government officials began getting the message. In 2000, despite ever growing subsidies, the Ministry of International Trade and Industry (MITI) minister publicly admitted that growing public opposition to nuclear power caused him to doubt whether the government could reach its goal of constructing 16 to 20 nuclear power plants by 2010 (a goal that never came close to being realized) (*Engineering News Record*, 2000). Similarly, a utility executive admitted in 2003: 'If we could, we would like to withdraw [from nuclear power generation]'.[7]

At the same time a proposal to begin using mixed oxide (MOX) fuel, which blends plutonium and uranium and is part of Japan's long-standing plan to build a closed nuclear cycle, in some of the reactors at the massive Kashiwazaki-Kariwa nuclear plant was derailed by public opposition. In May 2001 the village of Kariwa rejected using MOX fuel, and in a referendum at the end of the same month the city of Kashiwazaki also rejected the use of MOX, with 53.6 percent of voters opposing the idea. In November of the same year, the town of Miyama in Mie Prefecture held a referendum on whether to host a nuclear power plant: 67.5 percent of eligible voters cast ballots opposing the proposed plant; in response, the town's mayor promptly cancelled the planned plant (Hasegawa, 2004, p. 149).

Nonetheless, the overall direction of national policy remained unchanged as national public opinion continued to back the use of nuclear power. The 2003 version of the nation's energy plan continued to endorse reliance on nuclear power, including fuel reprocessing and the use of breeder reactors, 'based on the premise that safety will be guaranteed (O'Donnell, 2004).'

In 2003, revelations about nuclear accident cover-ups and a new and fatal accident at a nuclear power plant led to nationwide shutdowns of nuclear plants for safety inspections, drastically reducing the utilization rate for nuclear reactors. Tokyo Electric Power Company (TEPCO), Japan's largest electric utility, admitted to falsifying records at its nuclear plants, covering up significant safety incidents. In reaction to this revelation nearly all of Japan's nuclear power plants were taken off line during summer 2003, including 17 operated by TEPCO. The company's CEO and chief of its nuclear plants operations were forced to resign. Then, in August 2004, a high-pressure steam pipe burst at the Number 3 reactor at the Mihama nuclear power plant, killing four workers instantly and injuring several others (one of whom eventually died from injuries). Worsening the public reaction was the revelation that this section of pipe had never been inspected during the reactor's 28 years of operation. In response, the Kansai Electric Power Company (KEPCO) announced that it would shut down all of its 11 nuclear plants for inspections. In the wake of these incidents, a TEPCO official was quite candid about the eroding of public support: 'TEPCO lost public trust completely by the recent series of incidents (O'Donnell, 2004)'.

In this difficult environment, KEPCO, Chubu and Hokuriku electric power companies (EPCOs) bowed to years of local opposition in December 2003 and cancelled their long-planned nuclear plant in Suzu City, Ishikawa Prefecture. Three years later KEPCO cancelled plans for another plant in Kumihama in Kyoto Prefecture (*Japan Times*, 2006).

Nonetheless, public opinion at the national level did not abandon nuclear power during this period. Fifteen months before 3–11 a cabinet office poll found 59.9 percent supporting the use of nuclear power. However, 53.9 percent, an increase of more than 12 percent from the previous cabinet office poll, reported being uneasy about nuclear power due to cover-ups and a lack of transparency (*Asahi*, 2009b). Thus, the best way to characterize national public attitudes toward nuclear power on the eve of 3–11 was growing ambivalence. This growing ambivalence, plus growing opposition from local public opinion, caused Japan's nuclear expansion, measured in terms of electricity generation, to effectively grind to a halt.

Renewables, energy security, and public opinion

The 12 years between the Tokaimura accident and 3–11 also saw the emergence of renewable energy as a source of electricity and a nascent competitor to nuclear power. The Ministry of International Trade and Industry (MITI) had already become interested in renewable energy before the 1973 oil crises, when it started promoting solar power as a means to reduce Japan's dependence on oil and to create a new high-technology and export industry. MITI's 'Sunshine Program', which was launched in reaction to the 1970s oil crises, provided generous support for solar photovoltaics (PV) research and demonstration projects. Several private manufacturers participated and eventually managed to raise efficiency and decrease costs. By the early 1990s, the program's cumulative expenses had reached JPY 600 billion without realizing any major commercial successes. In response MITI shifted to promoting the commercialization of photovoltaics, including establishing technical standards for grid connection, convincing EPCOs to start a voluntary net-metering program, simplifying installation procedures, and providing incentives for the installation of residential PV systems. Once these steps were taken Japan's solar market began to take off (Kimura and Suzuki, 2006).

Wind power, on the other hand, was not championed by the Ministry of Economics, Trade and Industry (METI, MITI's successor), because it had not been viewed as a technology that could become a driver for Japanese exports. Investment subsidies were introduced for wind power projects in 1997, but their removal in 2007 discouraged further investments. In addition, wind projects became subject to much tougher environmental impact-assessment standards (which typically take two to four years) and construction standards than solar projects (*Asahi Shimbun*, 2013). Most importantly, wind projects frequently require large investments for grid connections, as favorable sites often are located far from urban load centres. This contrasts with residential PV panels that are installed on the rooftops of homes and are therefore already connected to the grid (Moe, 2012).

Moreover, regional electricity monopolies were reluctant to supply grid access to wind power, in part because of the danger that its intermittent nature might destabilize the grid. However, the main reason appears to have been concern that wind power might compete with nuclear power, a technology in which these companies had massive sunk costs. LDP Diet member Taro Kono told U.S. officials in fall 2008 that he suspected that the development of Hokkaido's abundant wind reserves was being thwarted by the regional electricity monopolies, which had unused power lines between Hokkaido and Honshu that they were refusing to utilize for transporting wind power (Wikileaks, 2008).

Although geothermal power is more costly than fossil-fuel electricity generation technologies, unlike wind and solar it enjoys the advantage of producing a stable output of electricity, allowing it to be used as a base-load power source. Thus, geothermal does not present grid-integration challenges. Japan, as a highly volcanic land holds the world's third largest potential for geothermal power (after the United States and Indonesia), estimated at 23.5 GW, more than half of Japan's current installed nuclear capacity (Think GeoEnergy, 2011). Nonetheless, as of 2010 Japan had only 18 geothermal power plants in operation, with an installed capacity of 0.53 GW (*Asahi*, 2010). The main obstacle is not cost, but rather the fact that the greatest geothermal potential is located in national parks, where Ministry of Environment (MOE) regulations make exploitation difficult. A second major obstacle is that geothermal faces surprising challenges from the country's traditional hot springs industry, which, despite an absence of evidence supporting its arguments, has so far been successfully able to claim that the exploitation of geothermal resources endangers the viability of nearby hot springs' operations (Ehara, 2013). Nonetheless, even before 3–11 METI was collaborating with MOE to reduce regulations hindering geothermal plant development.

Attempts to more comprehensively promote renewable energy in Japan took off in the late 1990s. In 1998, based on smaller local movements launched in the 1980s, a citizens' movement emerged, advocating a 'natural energy promotion law' and attracted support from 250 members of the Diet from various parties. This movement was inspired by the early success of Germany's feed-in tariff (FIT) in promoting renewables. Politicians were motivated to join a growing movement that appeared to reflect public opinion, and by the erosion of public support for nuclear power. A group of Lower House Diet members established a Diet League for the Promotion of Natural Energy (Shizen enerugi sokushin giin renmei, 2013; Hasegawa, 2004, pp. 174–92), which among other things aimed to create a German-style FIT in Japan. Nonetheless, METI co-opted this movement and drafted its own bill that called instead for enacting a Renewable Portfolio Standard (RPS) scheme with very low renewable energy targets and Green Certificate trading that diluted the effect of the targets. The METI bill, not the grassroots bill, was enacted in May 2002 (Nihon wo tsukuru, 2002; Suwa and Jupesta, 2012).[8]

This METI law, the Act on Special Measures Concerning New Energy Use by Electric Operators, obligated EPCOs to use a set amount of 'new energy' as determined by ministerial notice every four years. 'New energy' under this law was defined as solar, wind, geothermal, small-scale hydro and biomass (including waste incineration). The law allowed companies to realize their targets by trading, including banking and borrowing of certificates between compliance periods, and for decreasing targets by implementing energy-efficiency measures. Although flexibility is generally a desirable characteristic for a policy instrument, this tool proved so flexible that it failed to effectively promote the diffusion of renewable power sources.

That the RPS did little to aid the promotion of renewable technologies in Japan was evident in the case of PV. Japanese companies had developed PV technologies that dominated global markets during the early 2000s. This dominance had been helped by government-financed assistance payments for promoting rooftop solar-panel installations, but by 2004 the FITs introduced in several European countries had helped promote the growth of foreign solar companies even while Japan ended its subsidy scheme. Consequently, new solar installations plummeted in Japan and Japanese PV makers' global market shares eroded. By the end of 2009 Japan's installed PV solar capacity, which had recently been number one, had fallen to about one eighth of global leader Germany's capacity (*Japan Times*, 2010).

Responding to this and rising energy prices, the LDP eventually passed the Act on the Promotion of the Use of Non-Fossil Energy Sources and Efficient Use of Fossil Energy Sources by Energy Businesses in 2009. Based on this law METI ordered revived subsidies for solar power, this time in the form of a FIT that took effect in November 2009. Even though this was a net FIT, buying up only the electricity produced by an installation in excess of its owners' consumption of power, this FIT produced an immediate response, with the volume of solar panels shipped domestically growing, in terms of generation capacity, nearly three times from 2008 to 2009, and five times by 2010. However, this FIT instrument was limited to 'non-commercial' use, had a low ceiling for maximum capacity, and did not provide assistance to other renewable generation technologies.

In August 2009 the LDP, which had been in power as the leading governing party for all but nine months since 1955, was cleanly removed from office by voters, and the Democratic Party of Japan (DPJ) was swept into power. The winning party had promised as part of its ambitious package on climate change to expand the previous administration's FIT to cover other forms of renewable energy. Although the government had barely begun implementing the net FIT, November 2009 saw the establishment of a Hatoyama administration project team to design a FIT for renewable energy that would pay producers for the total amount of electricity generated across a wide range of renewable technologies, a gross FIT. In a step toward giving renewables a meaningful role in Japan's energy security strategy, the revised Basic Energy Plan, adopted under the Kan cabinet in June 2010, called for renewables to generate 20 percent of Japan's electricity supply by 2030, even while it also called for increasing the share generated from nuclear power up to 50 percent (METI, 2010, p. 11). Eventually, on March 11, 2011, the Kan cabinet approved a METI-drafted bill for submission to the Diet a few hours before the Great East Japan Earthquake struck.

Not surprisingly, the lack of effective policy instruments to promote the growth of renewable energy sources, combined with an unfavorable regulatory environment and even open hostility from electric power companies in the case of wind power, meant that renewables experienced only modest growth compared with growth in other countries, most notably China, Germany, and the United States. As already mentioned, METI, EPCOs, and others in what in Japan is often called 'the nuclear village' (composed of those with vested, or at least ideological, interests in nuclear power), were not supportive of renewable energy, seeing it as a competitor to nuclear power, and thereby a threat to the huge investment they had sunk into nuclear, not only in terms of physical capital, but also human capital. Moreover, Japan's nuclear power plants, although a power base-load, are not well designed to complement variable wind and solar power, as these reactors can take several days to start up and power down. Hostility toward renewables meant that EPCOs were not only often reluctant to give renewable energy projects grid access, as representative Kono alleged, but also that they were hostile to all but the most conservative of smart-grid proposals that emerged in the years immediately before 3–11 (*Asahi*.com, 2009).

More crucially, in an environment of growing public skepticism and ambivalence about nuclear power, renewables, although still a tiny source of electricity generation, threatened to further drain away public support for nuclear power by potentially presenting a viable alternative. Renewables, in short, at this stage presented more of a political threat than an economic threat. The nuclear village responded by attempting to convince the public that politicians such as Kono, who claimed that Japan would eventually 'move to 100 percent renewable energy' (Wikileaks, 2008), were wrong, and that there was no alternative to nuclear power for ensuring Japan's energy security and reducing energy imports.

Although still small in terms of generating capacity, renewables were already overtaking nuclear power in terms of public support. While support for relying on nuclear power remained well over 50 percent in the years just before 3–11, 64 percent of respondents in a November 2007 *Asahi Shimbun* poll favored promoting the development of renewable energy[9] for the sake of reducing greenhouse gases, even if this temporarily increased the cost of electricity, versus 26 percent who did not support this and 10 percent who were undecided or did not answer. By comparison, the same *Asahi* poll found that 49 percent of respondents thought that it was appropriate for government to promote nuclear power-generation as one pillar of its global warming reduction strategy despite the noted safety concerns about nuclear power, versus 33 percent who did not consider this appropriate and 18 percent who were undecided or did not answer (*Asahi*, 2008). Thus, even before 3–11 a larger percentage of the public was more willing to put up with the higher electricity prices that greater reliance on renewable energy might bring than were willing to accept the safety risks posed by nuclear power.

METI, the EPCOs, and others in the 'nuclear village', responded by attempting to depict renewables as insignificant boutique power sources. For example, the government's National Nuclear Energy Plan included an estimate that to produce the same amount of electricity generated by a single nuclear reactor, all of downtown Tokyo would have be covered in solar panels (*Asahi*, 2009a). Clearly this extreme analogy was an attempt to ridicule the viability of solar power as a source of electricity.

Nonetheless, solar energy, at least, was not a political orphan; wind power was the true political orphan (Moe, 2012). *Asahi Shimbun*, in an editorial in mid-March 2009, called for adding the development of third-generation photovoltaic technology, so-called 'quantum dots' technology, to Japan's 'Science and Technology Basic Plan'. The newspaper noted that by contrast this plan included the development of fast-breeder reactors as a goal and criticized the plan as unbalanced as a result. Nonetheless, even for *Asahi*, the promotion of PV technology appeared to be more of an export and commercial strategy and only secondarily an energy security strategy. According to the editorial, research on 'quantum dots' technology could raise PV efficiency beyond the then-current 10–20 percent range to over a 50 percent range, and Japan's leadership in this technology could help the Japanese electronics industry's 'efforts to recover their past glory (*Asahi Shimbun*, 2009a)'. Thus, before 3–11, and especially before the DPJ came to power (see above), PV solar was often depicted as being more a promising economic opportunity than as an answer to energy insecurity; nuclear power dominated the energy security policy space.

The impact of 3–11 on public opinion

The Great East Japan Earthquake of March 11, 2011 was of record-breaking magnitude for Japan in the modern era of seismology; the magnitude 9 quake triggered a tsunami that reached 40 meters at its highest point and swept more than 10 kilometers inland. In many ways the nuclear accident at the Fukushima Daiichi nuclear plant triggered by the quake and tsunami proved to be just as devastating, especially as its effects are in many respects longer lasting and more difficult to recover from. Four of the reactors out of the plant's total of six reactors had their containment buildings destroyed by hydrogen explosions, and three of the reactors experienced meltdowns. The Fukushima accident thus became the worst nuclear accident since Chernobyl, 25 years earlier. Approximately 80,000 residents in a 20-km radius surrounding the plant were evacuated, and many evacuees face years of little or no access to their deserted homes until radiation levels fall to a safe level (Srinivasan and Rethinaraj, 2013, pp. 729–30).

In response to this unfolding nuclear disaster the Japanese public, not surprisingly, started updating and rethinking its attitudes and opinions about nuclear power. One indication of this can be seen in Figure 4.5, which presents the results of an *Asahi Shimbun* poll question that asked: 'Do you support or oppose using nuclear power to generate electricity?' Asked one month after the nuclear accident, one half of the respondents still supported relying on nuclear power, versus only about one third who did not: this represented only a modest drop in support for nuclear power compared with polls in the years immediately preceding 3–11. Nonetheless, from that point forward public support for nuclear power gradually but steadily eroded, so that by fall 2011 the percentages opposing and supporting reliance on nuclear power were approximately the inverse of what they had been in April. By December nearly 60 percent opposed relying on nuclear power. This slow, but steady erosion was especially bad news for nuclear power advocates, as it indicated a gradual but steady rethinking of nuclear power rather than a short-term knee-jerk reaction that elitists would have expected.

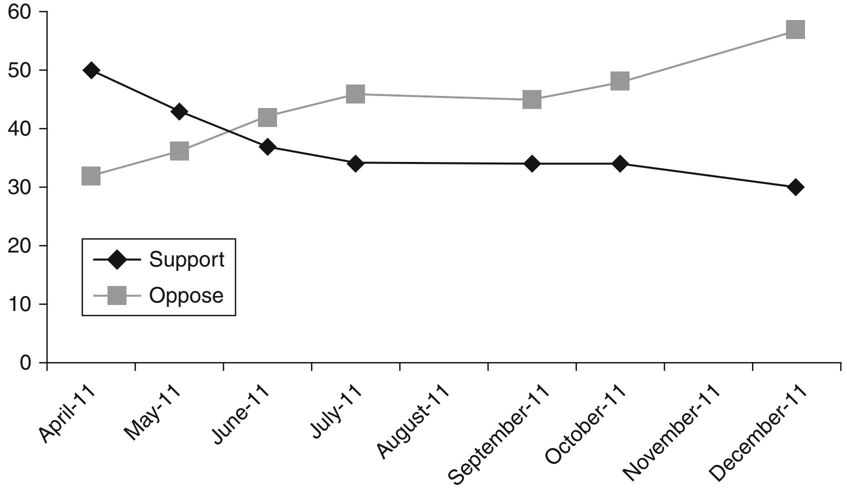

Figure 4.5 *Asahi Shimbun* poll on support for relying on nuclear power
Source: *Asahi Shimbun*, various dates.

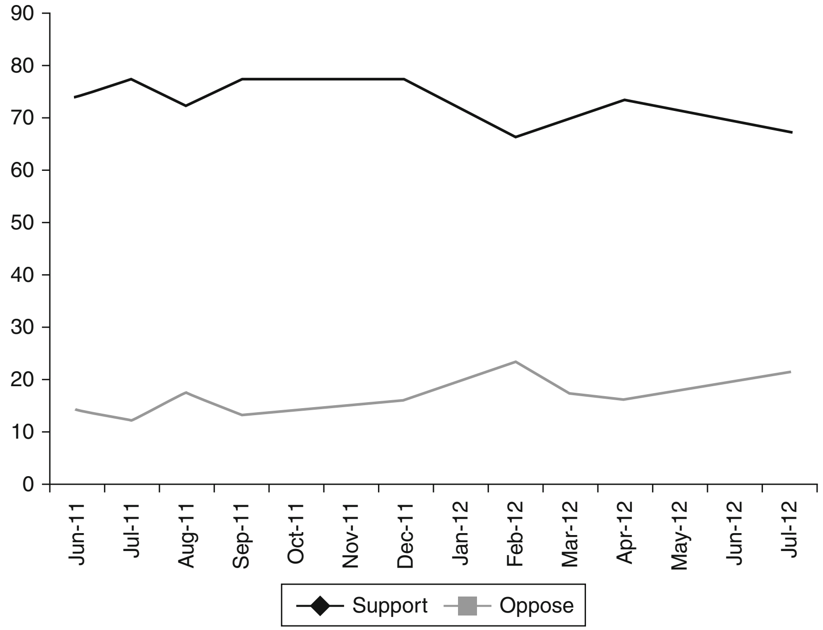

Figure 4.6 *Asahi Shimbun* poll on gradually phasing out nuclear power
Source: *Asahi Shimbun*, various dates.

Another *Asahi* poll question that was used repeatedly from June 2011 and asked about support for the gradual phase-out of nuclear power[10] found even greater support for this idea. The results can be seen in Figure 4.6, which shows that between June 2011 and July 2012 a stable majority of at least two-thirds consistently supported the gradual phase-out of nuclear power in response to repeated iterations of this question. By contrast, less than a quarter opposed this idea. The key phrase in this question is 'gradual phase-out', and the higher support for this idea versus opposing reliance on nuclear power indicates that a significant number of Japanese, while favoring the gradual phase-out of nuclear power, nonetheless believed that it was impossible to abandon nuclear power in the short run. This distinction, which many in the public made between immediate and gradual phase-out, would come to have crucial political and policy implications by the middle of 2012.

Other media polls found comparable results. In June and July 2011, the right-of-center *Yomiuri Shimbun* asked respondents: 'Japan has relied on nuclear energy to generate nearly 30 percent of its electricity. From now on what should be done with domestic nuclear power plants?' In response that June, a total of 61 percent of respondents said Japan should either reduce (45 percent) or eliminate entirely (16 percent) Japan's nuclear plants, a number that by July rose to 65 percent (reduce: 46 percent, eliminate: 19 percent). Over these two months those supporting the status quo fell from 32 percent to 29 percent, while those supporting an increase in the number of nuclear power plants remained steady at an almost statistically insignificant 2 percent (*Yomiuri*, 2011a; *Yomiuri*, 2011b).

Renewable energy, which already had the edge in public opinion before 3–11, now entirely eclipsed public support for nuclear power. Another *Asahi* poll question in June 2011 asked: 'Should the share of natural energy be increased even if electricity prices rise as a result?' In response, a lopsided majority of 65 percent answered yes, versus only 19 percent who answered no, and 16 percent who did not answer or did not know. Strikingly, the number supporting an increase in the use of renewables even at the cost of higher electricity prices was essentially unchanged from the 64 percent who in November 2007 answered that they would accept higher energy prices for the sake of reducing greenhouse gases. If the pre-3–11 large majority willing to pay more for electricity for the sake of promoting renewables essentially did not expand as a result of the Fukushima nuclear accident, this result nonetheless confirmed the existence of a stable majority of nearly two-thirds of Japanese who were willing to pay more in electricity bills to support renewables, whether for environmental or safety reasons. At the same time those opposed to the idea of promoting renewables did shrink significantly from 26 percent down to 19 percent. Another question in the same poll found that a similarly large majority believed that renewable energy would replace nuclear generation of electricity in the future:

64 percent thought this would happen, versus 24 percent who thought this would not happen, and 12 percent answered 'do not know' or 'no answer' (*Asahi*.com, 2011a). On the other hand, it is worth noting that the public's safety concerns regarding nuclear power meant that the short-term consequences of reduced dependence on nuclear power for Japan's greenhouse gas emissions, namely a large increase in emissions, tended to get overlooked.

Along with the shift in public opinion came a shift in the media debate about nuclear power and even energy security. The nuclear village essentially lost control of the energy security policy space. Renewables were for the first time considered seriously as a solution for Japan's energy insecurity.

At the same time the media increasingly began to scrutinize attempts by the EPCOs and METI to manipulate public opinion and the political process to facilitate the expansion of nuclear power. For example, in early 2012 it came to light that at least 19 members of municipal and prefectural legislatures were still on the TEPCO payroll, even after their election, a fact that had not previously been made public. These assembly members were elected to local governments in areas where TEPCO was either the electricity monopolist or else was operating nuclear reactors. These assembly members also continued to belong to the TEPCO labor union and received political donations from the union. These TEPCO employees-turned-assembly-members used their positions to write reports favorable to nuclear power and, in one case, blocked the Chiba Prefecture assembly from passing a resolution advocating a reduction in reliance on nuclear power and separating the generation and distribution of electricity into different companies (*Japan Times*, 2012). Another media investigation found that TEPCO and other EPCOs funneled large campaign contributions to the LDP through individual donations by power-company executives and middle management. In the case of TEPCO, contributions were 'voluntary' but expected, while coordination with the LDP's fundraising arm ensured that TEPCO could confirm that its managerial employees were indeed contributing to the LDP (*Asahi.com*, 2011b). Another survey found that over 70 percent of individual donations to the LDP's political management fund came from current and former executives of the EPCOs. The fact that these contributions were mostly clustered in December, when year-end bonuses are paid, were consistent according to title (presidents contributed ¥360,000, vice-presidents ¥240,000, and lower executives ¥100,000), suggests they were coordinated by the companies themselves (Kingston, 2012, pp. 199, 205).

The media also reported revelations about EPCO employees attempting to manipulate local meetings about nuclear plant policy. Most notably, three months after 3–11, Kyushu EPCO conspired with the governor of Saga Prefecture to manipulate the comments received by a government-sponsored TV program about whether to restart the Genkai nuclear plant in the prefecture (Brasor, 2011; Kyodo, 2011b). Increasing media scrutiny of the

EPCOs and other members of the nuclear village was, in turn, fueled by a growing number of leaks from METI and the EPCOs themselves, suggesting that in the aftermath of the Fukushima nuclear accident increasing numbers of village members were privately turning against nuclear power.

The shift in public opinion away from nuclear power encouraged shifts in interest groups and political parties. Most notably, the labor confederation, Rengo, which includes the union representing EPCO workers (including those who work at nuclear power plants), dropped its pro-nuclear position. In October 2011, abandoning support for building new nuclear power plants, Rengo nonetheless concluded that nuclear power could not be eliminated immediately, and that some nuclear power plants should be restarted in the short run, with gradual phase-out. How long this phase-out should take was not specified, however. Rengo proposed, in place of nuclear power, aggressively promoting the use of renewables (*Asahi Shimbun*, 2011; *Japan Times*, 2011a, b).

Even the traditionally pro-nuclear LDP, bowing to public opinion, began rethinking its stance. The LDP formed a new internal panel to review the party's energy policy, a so-called 'zero-based review' designed to question all assumptions, including reliance on nuclear power (Nagata, 2011). Of course, the LDP had always included some anti-nuclear politicians such as Taro Kono. In the wake of the Fukushima accident, even one of the nuclear industry's original proponents, former prime minister, Nakasone, changed his position and urged Japan to rely on solar power instead (Suzuki, 2011). Former LDP member Junichirou Koizumi, one of Japan's most popular and successful prime ministers of the post-war era also turned against nuclear power, and although retired from politics, by 2013 became increasingly outspoken in his opposition (Brasor, 2013).

From public opinion to policy

The gradual shift in national public opinion against nuclear power in the early months after the Fukushima nuclear accident was mirrored in an equally gradual move by the Kan cabinet away from promoting nuclear power and toward embracing renewable energy. First, on March 31 Prime Minister Naoto Kan announced that Japan's Basic Energy Plan would be rewritten from scratch and the role of nuclear power rethought (Fackler and Pollack, 2011; Scalise, 2012, p. 140). In May Kan took the initiative by ordering the shutdown of the Hamaoka nuclear plant in Shizuoka Prefecture south of Tokyo. This plant, like the Fukushima Daiichi plant, had long been identified as not having a sufficiently high tsunami wall. Two months after 3–11, Kan cited as the reason for his decision to act pre-emptively before a disaster struck this plant: the possibility of it being inundated by a tsunami generated by a nearby active fault. In response, the public strongly supported Kan's decision. A Nippon TV poll found that 71.2 percent supported the decision, versus 17.3 percent who opposed, and 11.5 percent who did not know or did not answer (NTV, 2011).

Public opinion began having an even more dramatic impact at the local level, as local governments, responding to the concerns of local citizens, refused to provide consent to restart nuclear reactors shut down for regular maintenance. With reactors required to shut down every 13 months this meant that the number of online reactors steadily declined after 3–11. Although in June 2011 METI mandated a number of measures to deal with some of the problems that had led to the Fukushima accident, local governments were unmoved. Eventually, local authorities in Saga Prefecture began preparing to authorize the restart of the Genkai reactor there. However, Prime Minister Kan then intervened and ordered that all nuclear plants would have to pass a set of rigorous stress tests before being allowed to restart, thereby delaying the restart of Genkai and other plants (Ito, 2011).

In July, Kan went further, announcing that Japan should give up its reliance on nuclear power, although he emphasized that this could not happen immediately. He also did not lay out a plan specifying how to do this (Prime Minister's Office, 2011). Nonetheless, Kan's declaration in favor of ending reliance on nuclear power received significant public support. In a Kyodo poll conducted about ten days after Kan's announcement, 70.3 percent expressed support (31.6 percent) or qualified support (38.7 percent) for his declaration. This high rate of support came despite the fact that Kan's cabinet itself was only supported by 17.1 percent in the same Kyodo poll (Kyodo, 2011a). In light of the public's support for Kan's non-nuclear declaration, he was able to convince his cabinet to turn his personal statement into official cabinet policy (Kingston, 2012, p. 198).

Although Kan was criticized by the LDP and other opposition parties for failing to come up with a plan specifying the timing and means for achieving a zero-nuclear Japan, Kan accompanied this shift with a series of policy initiatives designed to move Japan in this direction. First, he proposed a more ambitious FIT than the one his government had approved on March 11. Among other things, METI was stripped of its power to appoint the members of the tariff-setting committee, and this power was transferred to the Diet. Kan also proposed a bill stripping METI of its responsibility for nuclear safety, and setting up a new and independent Nuclear Regulation Authority (NRA) that would devise a new set of safety guidelines for nuclear plants. Kan also suspended Japan's exports of nuclear reactors and proposed separating power generation and transmission in order to give renewable energy producers better access to the grid (Kingston, 2012, p. 198). These policy proposals appeared to enjoy broad public support. The same July 2011 Kyodo poll found 78.2 percent supported Kan's feed-in tariff bill, while only 14.2 percent were opposed (Kyodo, 2011a). Indeed, the otherwise unpopular Kan was able to leverage support for the FIT bill into an extended life for his cabinet by refusing to resign until the Diet enacted the bill.

Nonetheless, Kan left office before he was able to enact new laws on nuclear safety and divesting the EPCOs of their control over the grid. Kan's successor, Yoshihiko Noda, broadly supported Kan's energy policies, but was more cautious. One reversal he made was to end Kan's suspension of nuclear reactor exports (Kyodo, 2011c). Nonetheless, Noda aligned himself with efforts to enact new laws setting up the Nuclear Regulation Authority (NRA) and promoting grid divestiture. A more immediate challenge that Noda faced was the gradual shutdown of nuclear power plants across Japan when their regular 13-month inspections came due. In May 2012 the last nuclear power plant shut down, leaving Japan with no operating nuclear power plants for the first time in approximately 45 years. Public opinion showed significant opposition to restarting nuclear power plants, although significantly more respondents favored short-term restarts than favored relying on nuclear power in the long run. In a February 2012 *Yomiuri Shimbun* poll 37 percent favored restarting nuclear power plants that passed 'regular safety inspections', versus 53 percent who opposed restarts, and 10 percent who were unsure or did not answer (*Yomiuri*, 2012). A week later, a *Nikkei* poll that asked whether nuclear reactors should be restarted 'if they passed government tests' (which could be interpreted as including Kan's stress tests), found that 41 percent favored restarts versus 43 percent who opposed (*Nikkei*, 2012).

By April attention began to focus on two reactors at the Oi nuclear plant in Fukui Prefecture that the government wanted to restart as the country headed toward a shutdown of all nuclear plants. An *Asahi* survey asked whether respondents favored the restart of the two Oi nuclear reactors. Only 28 percent of respondents approved restarting the reactors, versus 55 percent who opposed. Moreover, 70 percent said they distrusted the temporary safety standards the government had come up with for ensuring the restart, versus 17 percent who trusted these standards; and 66 percent distrusted government and KEPCO estimates that the Kansai region would not have enough electricity during the summer if the reactors were not turned back on. Finally, 88 percent said that reactors should not be turned back on without the approval of host communities, and 83 percent of respondents who so answered also answered in a follow-up question that the approval of nearby municipalities and prefectures was also necessary before restarts proceed (*Asahi*, 2012a). In short, only a small plurality opposed the restart of nuclear power plants that passed rigorous safety tests, but large majorities opposed restarts in the absence of new and stringent guidelines. The public was not willing to tolerate hasty restarts.

The net impact of public opposition was to delay the restart of the Oi reactors until early July, two months after all functioning reactors had been stopped. More significantly, the Noda administration bowed to public opposition by deciding against restarting any other reactors before the new NRA was formed and had devised new permanent safety guidelines. The Noda administration also decided to seek significant public input when formulating a new energy strategy during the same summer (Openheimer, 2013, p. 95).

In June, just as it was deciding to restart the Oi reactors, and just as it managed to pass legislation establishing the NRA, the Noda administration also proposed three options for Japan's energy mix by the 2030s. In the first option, nuclear power would provide 20 to 25 percent of Japan's electricity, renewables would provide 20–30 percent, and fossil fuels the remainder. This option would require building additional nuclear power plants to supplement plants shut down due to age. The second option would see Japan generate approximately 15 percent of its energy from a reduced number of nuclear power plants, with no new builds, 30 percent from renewables, and the rest from fossil fuels. The third option would see Japan eliminate nuclear power altogether, with renewables generating 35 percent of the country's electricity, and fossil fuels the rest (Oppenheimer, 2013, p. 95).

The Noda cabinet held a series of public meetings throughout the country to gather citizens' views on the three options. The views received overwhelmingly favored the zero-nuclear option. Media opinion polling also indicated that this was the most favored solution. An *Asahi* poll taken in July showed that 42 percent supported the zero option, with support for this option increasing to 43 percent by September. Twenty-nine percent supported the 15 percent nuclear option, a number that rose to 31 percent by September, and 15 percent supported the 20–25 percent option, a number that dropped to 11 percent by September. Another question in the same poll found that a total of 83 percent had great (29 percent) or moderate expectations (54 percent) about the potential of renewable energy such as wind and solar, versus 14 percent who had little (12 percent) or no (2 percent) expectations (*Asahi Shimbun*, 2012b).

Although the 15 percent nuclear option appeared to be positioned as the early favorite, as it was the option in between the two extremes of zero nuclear and (almost) the pre-3–11 status quo, the Noda cabinet, despite intense opposition from EPCOs and industry in general, bowed to public pressure and adopted the option of phasing out the use of nuclear power by the end of the 2030s, based largely on three principles: limiting nuclear reactor lifetimes to 40 years, no reactor restarts without the approval of the NRA; and no new construction of reactors. This option also mandated a three-fold increase in renewables or an eight-fold increase when large-scale hydro generation is excluded – for example in wind, solar, and geothermal (Energy and Environment Council, 2012).

Although the cabinet did not formally adopt this plan, it pledged to use it when adopting future energy policies. This statement was thus similar to a chief cabinet secretary 'danwa' or statement, in that it carries significant authority despite not being a formally adopted cabinet position. Noda himself reinforced the authority of this cabinet statement when in late September he declared to the UN General Assembly that Japan aimed at realizing zero reliance on nuclear power by the 2030s. However, contradictions in the government's position quickly emerged as the METI minister announced that he was considering allowing the Oma plant in Aomori prefecture, already under construction, to be finished; the Noda cabinet also refused to officially cancel the fast-breeder reactor program (*Japan Times*, 2013).

Energy policy in a new election and under a new government

Two months after the Noda cabinet had decided on nuclear phase-out by the 2030s, Noda dissolved the Diet and called new elections for the Lower House. The DPJ and the prime minister were both very unpopular. At its base, this unpopularity did not stem from distance between the party's positions and public opinion, but from public doubts about Noda and the DPJ's ability to implement their policies. Contradictions in DPJ policies, including in energy policy, also damaged the party's image.

Consequently, the LDP and its coalition partner Komeito won a huge election victory; the LDP almost won as many seats as the DPJ had in 2009. To what extent did energy policy play a role in this outcome? The answer, in short, is that energy policy did not play much of a role, but not because voters did not care about this issue. Table 4.1 presents the results of exit polling conducted by *Asahi* on the day of the lower house election.

Among the major political parties, the LDP was the only one that did not promise to phase out nuclear power, whereas Komeito was the only party among those pledging to phase out nuclear power that refused to set a specific date for doing so. All the other political parties gave specific dates for phasing out nuclear power: from the end of the 2030s in the case of the DPJ, to the early 2020s in the case of the small Your Party (YP) and Tomorrow Party Japan (TPJ). Table 4.1 indicates that the LDP, as the least anti-nuclear power party, benefited by attracting the lion's share of votes from those opposed to phasing out nuclear power. Similarly, the short-lived Tomorrow Party Japan, which was co-founded by anti-nuclear activists, did disproportionately well among voters who support the immediate elimination of nuclear power. In the case of other political parties there is little evidence of voting based on nuclear power as an election issue. What this reflects is not apathy about nuclear power, but rather the muddled positions of the other major parties, especially the ruling DPJ. Of the parties that listed a date for phasing out nuclear power, the DPJ's date was the latest, coming only at the end of the 2030s. In addition, as mentioned above, the Noda administration had a very contradictory policy on nuclear phase-out as it signalled that some plants that were already under construction could resume construction, and as it did not formally close down the country's breeder-reactor program. The Japan Renaissance Party (JRP), had an even more contradictory energy policy, with the two heads of the party, former

Tokyo governor Shintarou Ishihara and Osaka mayor Toru Hashimoto issuing directly conflicting statements about whether the party supported nuclear phase-out. Although the YP had a clearer anti-nuclear stance, its election alliance with the very conflicted JRP appears to have confused voters about YP's stance on nuclear power as well. Consequently, with the exception of the poorly organized start-up party TPJ, or the Communists, voters had difficulty finding a purely anti-nuclear power party to vote for.

Another factor that affected voting behavior was that even the LDP, the most pro-nuclear party, failed to criticize the Noda administration's policy of phasing out nuclear power by the end of the 2030s. Indeed, the LDP joined the other major political parties in its election manifesto by calling for 'introducing renewable energy as much as possible'. The same manifesto even contained a Kan-like statement when it advocated 'creating economic and social structures that can be strong even without relying on nuclear power'. Kicking the can down the road the LDP pledged to come up with a new energy strategy within ten-years while delegating decisions about restarting existing plants to the NRA (Jimintou, 2012, pp. 23–4). By not challenging the Noda administration's nuclear phase-out plan the LDP thus was able to run as the least anti-nuclear party while simultaneously not provoking the large majority of Japanese voters who favor gradual nuclear phase-out. On the other hand, the implication of this strategy is that the LDP risks a serious voter backlash if it should overturn the nuclear phase-out policy and advocate maintaining nuclear power, and especially if it should again seek to expand it.

Neutralizing energy policy as an issue helped the LDP to win a large electoral victory in a lower house election that was largely fought on economic issues and was a referendum on DPJ policy competence. Although the LDP won a stand-alone majority in the lower house, the party nonetheless continued to rely on its long-standing coalition partner, Komeito, both to give them a two-thirds majority in the lower house and to help the LDP achieve a near-majority in the upper house. The support of Komeito's organized electoral base, which relies on the lay Buddhist organization Soka Gakkai, is also key for LDP success in many electoral districts. Although Komeito did not specify a date for phasing out nuclear power in its 'election manifesto', it clearly staked out an anti-nuclear position, calling for the

Table 4.1 Position on using nuclear power?

	Overall	DPJ	LDP	TPJ	Komeito	JRP	YR
Zero immediately	14	16	16	13	7	14	8
Zero eventually	64	18	28	5	9	22	8
Oppose nuke zero	15	13	43	2	7	21	5

Source: *Asahi Shimbun* (2012c).

phase-out of nuclear power as soon as possible. When LDP prime minister, Shinzou Abe, hammered out a coalition agreement with Komeito, the two parties agreed to reduce Japan's dependence on nuclear power by relying more on renewable energy (Mie, 2012). This agreement reflected both the influence of Komeito and that of public support for nuclear phase-out.

Once in office Abe's coalition government acted largely along the lines laid out in the LDP's election manifesto and the coalition agreement with Komeito. Even while the Abe administration interfered with Japan's ostensibly independent central bank, it was careful to respect the independence of the NRA, even as it devised stringent, time-consuming and costly new safety guidelines for nuclear power plants. The Abe administration did not attempt to push for the speedy restart of nuclear power plants as the Noda administration had done with the two Oi reactors in July 2012. Indeed, the Oi reactors remained the only reactors online.

The Abe administration surprised many observers by embracing the policy of the Kan and Noda administrations to break up the regional EPCO electricity monopolies with a plan to separate transmission and generation. Revelations, reported in even the pro-nuclear *Yomiuri Shimbun*, revealed that an analysis of TEPCO's profits from 2006 to 2010 showed that they were disproportionately concentrated in residential sales to customers who were unable to choose their supplier; profits in sales to industrial users, on the other hand, were far lower, as they could choose alternative suppliers (*Yomiuri Shimbun*, 2013). The Abe administration essentially picked up where the Noda administration had left off, finalizing a bill drafted through METI, and inspired by Nordic models of electricity-sector reform that would separate transmission in three stages. In the first stage an Independent System Operator (ISO) is to be created by 2015 in order to regulate the flow of electricity through all national grids and regulate access to those grids. The second step involves deregulating the consumer market by 2018, thereby allowing consumers to choose their electricity provider. The third step, to be completed by 2020, will involve spinning off power transmission from the current regional electricity monopolies (Steffensen, 2013). The Abe administration introduced this bill in spring 2013, but it did not pass during the spring Diet session.

Many observers questioned whether the Abe administration's relatively restrained policies regarding nuclear power, and its promotion of renewables and unbundling transmission, reflected the cabinet's true preferences, or whether the LDP was simply biding its time until a crucial upper house election in July 2013. As one senior LDP politician put it on his Facebook page, the Abe administration was simply 'engaging in safe driving' before the election. According to this view, if the LDP and Komeito won a majority in the upper house, and especially in the unlikely event that the LDP won a stand-alone majority, Abe would start to show 'his true colors'. The LDP essentially repeated its cautious 2012 lower house election manifesto's language regarding energy policy in its 2013 upper house election manifesto, promising not to restart any plants until they were judged safe by the NRA, and local consent had been obtained (Kyodo, 2013).

Although the LDP did not win a stand-alone majority in the upper house election in July, it did gain a majority together with its coalition partner Komeito. Whether for this reason, or simply because the pundits' understanding of the Abe administration was wrong, in the first several months following its victory in the July elections the Abe cabinet continued the same policies. It continued to promote renewables and moves to break up regional electricity monopolies and foster consumer choice. The Abe administration reintroduced the bill unbundling the EPCOs in the fall Diet session, and succeeded in passing it during that session.

Even while it was promoting renewables and the breakup of regional electricity monopolies, the Abe administration nonetheless took a cautious and 'hands off approach' to restarting nuclear power plants. Indeed, even though EPCOs filed applications with the NRA to restart a dozen nuclear reactors in July 2013, the stringency of the new safety requirements and the NRA's own careful deliberations meant that no nuclear reactors were expected to be restarted before summer 2014. In the meantime, the two Oi reactors restarted by Noda in July 2012 were shut down again in September 2013 for their regular 13-month inspections, with the NRA not agreeing to allow their restart before they also satisfied the new safety guidelines. Thus, for only the second time since the mid 1960s, Japan was again nuclear free, only this time the period of no nuclear power under LDP rule was expected to last more than six months, far longer than the two-month period of no nuclear power experienced under DPJ rule. Although Abe himself was known to be personally very much in favor of nuclear power, overwhelming opposition to nuclear power seriously limited his ability to pursue pro-nuclear policies. Once again, politicians were bowing to the power of an overwhelming and stable public opinion majority.

Conclusions

This chapter has traced a growing conflict between public opinion and elites, with elites supporting nuclear power while public opinion, first on the local level and then after 3–11, on the national level, opposing it. This is thus a good case for testing the influence of public opinion versus elites on policy, and thus the predictions of elitist and pluralist models of public opinion. The results of this chapter tend to support the pluralist model. Even relatively small increases in public opposition to nuclear power at the local level in the early years of Japan's ambitious nuclear expansion program significantly increased costs and slowed expansion. Public-safety concerns have even had a noticeable impact on the amount of electricity generated by nuclear power, not only by slowing the building of new plants, but also by reducing the utilization of existing plants, as plant operators have faced more stringent inspections and more difficulties obtaining local consent for plant restarts following accidents.

Even before 3–11 the public had become increasingly ambivalent about nuclear power. A stable nationwide majority continued to support relying on nuclear power even while concerns grew about safety and cover-ups of accidents. These concerns, especially at the local level, were already enough to effectively stymie Japan's ambitious plans, well before 3–11, for expanding the generation of electricity from nuclear power. Nonetheless, it took the Chernobyl-scale accident at the Fukushima Daiichi plant to convince many Japanese to rethink their support for nuclear power, causing what had been a stable majority favoring reliance on nuclear power to flip over to a stable majority in opposition to nuclear power. This flip did not happen overnight, and it was not an unstable or temporary phenomenon, as elitists would predict. Rather it was a slow and steady change, as pluralists would expect.

Given the scale and stability of the new majority, it is not surprising that it had a profound influence on public policy, swamping the best efforts of many pro-nuclear elites. During the 18 months following 3–11 Japan moved from planning to produce 50 percent of its electricity from nuclear power by 2030 to abandoning all nuclear energy by the end of the 2030s. At the same time Japan moved to drastically increase its support for renewables and to effectively break up regional power monopolies by divesting them of their control over regional grids and electricity transmission.

The scale of the change in public opinion, and the fact that it was a reaction to very costly and salient events, suggests that the stable majority opinion favoring the phase-out of nuclear power is likely to persist. While the public also appears willing to tolerate the short-term restarts of some reactors, it will only do so when it is evident that the strictest guidelines and procedures are being followed. There is no tolerance for political interference in the NRA. On the other hand, if the LDP or any other political party attempts to reverse the phase-out of nuclear power, they are likely to face retrospective voting and pay a heavy political price. Public opinion, not elites, therefore, has set the non-nuclear course that Japan has embarked upon. For that reason, it appears unlikely that Japan will reverse course.

Notes

1. This distinction especially characterizes the debate about the nature and role of public opinion in the United States, but has also been applied to other advanced democracies, including Japan. Regarding this debate and Japan see Midford (2011, ch. 2).
2. On the early history of nuclear power in Japan see Samuels (1987, ch. 6).
3. See Aldrich (2008, p. 127), who cites Soumuchou surveys from 1968, 1975, and 1976.

4. Koichi Hasegawa notes that after Chernobyl 'there was a large influx of women into the anti-nuclear movements, creating a new wave of anti-nuclear movements (Hasegawa, 2004, p. 128).'
5. In 1972 an anti-nuclear majority was elected to the town council of Kashiwazaki in Niigata Prefecture, and it proposed a referendum on whether construction of a nuclear power plant should be built there. That same year the town of Shika on the Noto Peninsula in Ishikawa succeeded in actually holding a referendum, but prefectural officials were able to block town officials from counting the votes (Aldrich, 2008, p. 130).
6. Although the construction of several new nuclear reactors were completed after Tokaimura, increased concerns over safety increased nuclear reactor downtimes that reduced utilization rates, meaning that this new capacity failed to translate into increased power generation.
7. As quoted by Aldrich (2008, p. 145).
8. Also see an undated manuscript by Tetsunari Iida, 'Igamerareta "Shizen enerugi shokushin hou"', p. 1, accessed October 15, 2013 at http://www.isep.or.jp/images/press/02iidaEnvSociology.pdf.
9. The term used was 'shizen enerugi' or 'natural energy', which was the term Asahi typically used during this period to refer to renewable energy (saisei kanou enerugi).
10. The question asked: 'Do you favor gradually reducing nuclear generation of electricity and eliminating it in the future? Are you opposed (*Asahi*.com, 2011a)?'

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Asahi Shimbun (2012b) 'Noda seiken, kiken suiki hairi', August 6, 2012, p. 3.

Asahi Shimbun (2012c) 'Minshu shijihyou, soukuzure', December 17, 2012, p. 1.

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5

China's Energy Security

Øystein Tunsjø

In less than two decades, China has gone from being a petroleum exporter (1992) to becoming the world's largest net oil importer (2013). How has China adapted to its increasing reliance on imported crude oil and petroleum products, and what strategies has China developed to strengthen energy security by reducing its exposure to potential supply disruptions and sudden price rises? The Chinese government has combined security and profit considerations to minimize the risk that increasing reliance on imported crude oil, exceedingly high oil prices and oil supply disruptions will negatively affect China's economic growth and domestic stability. China's leaders have also developed policies to manage and minimize the risk that the commercial interests of China's national oil companies (NOCs) would undermine China's diplomatic and national interests. These strategies and policies are best understood as hedging.

In examining China's energy security it is necessary to distinguish between peacetime risks and wartime threats contingencies. Much of the existing literature, analysis and commentaries disregard this important distinction. If China finds itself at war with the United States, the only great power capable of blockading China's oil imports, 'all bets are off' and China's seaborne oil supplies are likely to be disrupted. However, China does not depend on overseas oil supplies in a wartime contingency because of its large domestic oil production, its abundant indigenous energy reserves and because automobile usage, which will drive future oil consumption, can be curtailed.

Interestingly, it has been pointed out that in fiscal year 2004 the U.S. military, fighting wars in Iraq and Afghanistan and sustaining normal operations as well, used approximately 395,000 bpd of oil (Collins and Murray, 2008). Thus, China's domestic oil production, roughly 4 mb/d, is ten times more than what the U.S. needed to wage two wars and maintain its global military activity. About 90 percent of China's energy demand is provided for by domestic sources, with abundant coal reserves accounting for about 70 percent. As did Germany during WW II, China can make synthetic oil from its large coal reserves. Automobile usage is curtailed in Beijing today, and such a policy was implemented during the Olympics in 2008.

More importantly, a war between the U.S. and China is unlikely. The costs of such a conflict will be extremely high, and the possibility of such a war remains low. Hence, instead of focusing the analysis on unlikely wartime contingencies in which China has limited capacity to protect its oil imports, it is more rewarding to shift the analysis towards peacetime risks that cannot be eliminated but, instead, managed and minimized.

China's energy security can be defined as the ways in which high oil prices and disruption in oil supply may weaken China's economic growth and affect domestic stability, which is a core concern for the Chinese government. It is not primarily a question about 'securing' overseas sources of oil, 'controlling' vital sea lanes of communication (SLOC), 'locking up' oil supplies or 'waging war' over oil as some writers seem to suggest (Zhang, 2006; Luft, 2008; Hatemi and Wedeman, 2007; Klare, 2010a, b).

Risk can be understood as the possibility that a potential threat materializes. In theory, threats can be eliminated, whereas risks cannot. Rather, risks need to be managed. One way to conduct risk-management is to hedge, and the analysis below shows how China has hedged against potential oil-supply disruption, exceedingly high oil prices and a growing net oil-import gap. Risks of oil supply disruptions, such as a war in an oil-rich region (even if it does not involve China), embargo or sanctions against one of China's major oil suppliers, environmental disasters, terrorism, piracy and accidents at sea, all of which may inject a shock to the international petroleum market and result in oil-supply disruptions and a significant rise in crude oil and petroleum-product prices cannot be eliminated. Nonetheless, such risks can be minimized. Strategies to manage and hedge against the risk of oil-supply disruptions can be identified in China's official five-year plans (2001–5, 2006–10 and 2011–15), including maintaining a favorable energy mix; developing overseas equity oil production; building a state-owned tanker fleet; developing cross-border pipelines; building a strategic petroleum reserve (SPR); expanding refinery capacity; signing future and long-term contracts; participating in constabulary tasks overseas and diversifying its energy sources and routes. By focusing the analysis on China's energy security hedging strategies, this chapter shows how the government's concern about security of supply and the NOC's search for profits are linked.

Before examining China's hedging strategies and some of their implications, it may be useful to first summarize some data on China's role in world energy markets and present some of the main conventional approaches to explaining China's energy security policy.

China's oil needs

China became a net importer of oil in 1993. Since then, China has had an astonishing increase in demand for crude oil, surpassing most, if not all, forecasts, projections and estimates. In 2009, China for the first time imported more than half of its crude-oil consumption. The International Energy Agency (IEA) projects that in 2030 China will import 79 percent of the oil it consumes, accounting for 22 percent of world demand, up from 17 percent in 2010 (IEA, 2010). In 2011, China's oil consumption stood at approximately 9.6 mb/d (Platts, 2011).

The data vary on overseas investments, mergers and acquisitions, and loan-for-oil deals, and there are hundreds of different estimates and numbers that can be referred to. But the following can provide a general picture:

- China's NOCs have invested, and are involved, in upstream projects all over the world. They started out in Central Asia and Russia, then became more active in Africa and Latin America, and are now even key players in the Middle East, recently signing major contracts in Iraq. Some researchers estimate that China's NOCs have a stake in roughly 200 upstream investment projects in 50 countries (*Oxford Analytical*, 2010; Kong, 2010), while the IEA reports that 'Chinese oil companies are now operating in 31 countries ... ' (Jiang and Sinton, 2011).
- Chinese NOCs, along with other smaller companies from China, spent at least $47.59 billion to acquire oil and gas assets around the world from January 2009 to December 2010, and spent $18.2 billion on mergers and acquisitions (M&A) in 2009, which accounted for 13 percent of total global oil and gas acquisitions ($144 billion), and for 61 percent of all acquisitions by national oil companies ($30 billion). In 2010, Chinese NOCs spent approximately $29.39 billion again with more than half invested in Latin America ($15.74 billion) (Jiang and Sinton, 2011, p.10).
- According to the IEA, from the beginning of 2009 to December 2010, China's National Petroleum Company (CNPC) and Sinopec were involved in 12 loan-for-oil deals with nine countries worth an estimated $77 billion. If we add Kong's estimates that '[A]s of September 2009, Chinese overseas petroleum investment has grown above $60 billion' (Kong, 2010, p. 67), we find that China has invested at least $137 billion in oil-for-loan deals.[1]
- The data on overseas oil production by China's NOCs is difficult to access, but it is reasonable to conclude that China's NOC overseas production now stands at roughly 2 mb/d, with equity oil production accounting for approximately 1.4 mb/d.

In short, as the IEA writes: 'It is hard to overstate the growing importance of China in global energy markets' (IEA, 2010). For most analysts the increasingly prominent role of China in global energy markets carries both strategic and commercial implications.

Traditional approaches to China's energy security policy

From an alarmist view there are a number of writers and policymakers who argue that states are strategically competing for limited energy resources to power their economic growth (Klare, 2008; Victor and Yueh, 2010; Kaplan, 2009). Such a perspective often presents scenarios whereby China's quest for overseas oil supplies leads to rivalry and confrontation (Canning, 2007; Levrett, 2007).

Given the rapid expansion of China's NOCs into the world energy market we find alarmist views not only from actors with a strategic outlook, but from commercial ones as well. China's NOCs are seen as an arm of the government seeking unilaterally to secure China' energy needs by a neo-mercantilist 'lock up' supply strategy (Lee, 2012; U.S. NSS, 2006). When China's National Offshore Oil Company (CNOOC) Limited presented its bid for Unocal in 2005, the vice chairman of Chevron, who had a competing bid, complained that 'We're not competing with this company; we're competing with the Chinese government'. Largely because certain terms of loan packages are not available to Western publicly traded companies – because China's NOCs obtain loans with very low interest and gain diplomatic support or benefit from China's diplomacy and loan-for-oil deals – many industry experts argue that it is becoming increasingly difficult to compete with China's NOCs (Downs, 2010). Even a top executive from the Norwegian oil company Statoil half-jokingly stated to the author that the Chinese simply add a zero to any bidding competition.

Conversely, many market-oriented writers point out that instead of taking oil off the market, Chinese oil companies are investing in the few remaining underdeveloped oil regions of the world and contribute to a better-supplied world oil market (U.S. DOE, 2006, p. 3). The world energy market should also be seen as one big pool of oil. If China seeks oil supplies from Sudan or Iran, it buys less elsewhere, which means there is more oil available to other consumers (Herberg, 2007).

Instead of shipping its overseas oil production back home in a neo-mercantilist fashion, China's NOCs largely sell their overseas oil production locally or in the international petroleum market. They have often paid more to get a stake in overseas equity oil production, found it hard to compete with established International Oil Companies and taken higher risk by settling for 'low hanging fruits'. However, China's NOC strategies to get a foothold in the world energy market are not much different from the strategies adopted by major Western companies. Economic and diplomatic support from home is nothing new, and the Chinese oil companies are not the first to cooperate with authoritarian regimes, providing them with arms and overlooking humanitarian, social and environmental needs in order to advance petroleum interests.

Advocates of the strategic and alarmist viewpoint are challenged by those emphasising growing interdependence, common goals, cooperation in maintaining stability in the world oil market and by the fact that the liberalization of international and domestic energy markets can prevent disruption of oil supply by improving the flow of information and promoting investments in new capacity (Dirks, 2007; Houser and Rosen, 2007; Houser and Levy, 2008; Zha and Hu, 2007; Zha, 2006).[2]

Much has been written about China's energy security policy, and many publications take on an 'either/or' perspective. China's energy security policy is either guided by strategic and mercantilist ambitions or shaped by market mechanisms. It is either organized and controlled by the government or manipulated by powerful NOCs pursuing their corporate and commercial interests (Andrews-Speed, 2006; Andrews-Speed et al., 2002; Godement, 2004; Constantin, 2007; Haider, 2005; Zha, 2010). This present study emphasizes a 'more or less' perspective. Both market and strategic considerations shape China's energy security policy. In some cases the energy companies' search for profit may be most important. In other cases it may be the government's concern about security of supply that is the main factor.

There are, of course, a number of scholars who provide a more nuanced analysis than the dichotomized debate implies (Cornelius and Storey, 2007; ICG, 2008; Cole, 2008; Jakobson and Zha, 2006; Kong, 2005; Liu, 2006; Tang, 2006). Much scholarship combines elements of a market and a strategic approach in their assessment of China's energy security policy, often referred to as a comprehensive approach (Andrews-Speed and Dannreuther, 2011; Downs, 2004; Kong, 2010; Lieberthal and Herberg, 2007).

Clearly, states mix strategic and market strategies for securing energy supplies, and my objective is not to jettison traditional approaches. However, most studies do not provide a theoretical framework for examining the balance and the linkage between market and strategic approaches. In the following analysis it is illustrated how the market and strategic elements in China's energy security policy are combined into hedging strategies that mix security and profit considerations.

Linking security and profit: a new framework for analysis

One way to address some of the complexity that is lost in the void and tension between 'strategic' and 'market' approaches is to link hedging to risk management. This is beyond semantics or simply replacing the word 'comprehensive' with 'hedging'. Instead, by broadening the analytical tools and incorporating hedging, important nuances can be explored, and the analysis can better explain China's energy security policy (Tunsjø, 2013).

In order to limit market risk and at the same time seek to be reasonably well off, some investors hedge by keeping a percentage of their portfolio on the 'short' side – that is, they bet that some stocks, currencies or food prices will go down. Since 'shorts' will make money in a down market, they act as a protection, a hedge, when 'longs' (assets believed will go up) perform poorly. One can never eliminate risk, but if a hedging strategy is thoroughly worked out, investments will not be dependent on whether a market goes up or down, as profit can be made either way.

It is this idea that has transfer value to international politics and energy security: No matter how the market develops and whether risks in the supply side materialize, a hedging strategy can leave China reasonably well off tomorrow. Hence, when Chinese leaders sense uncertainty about whether a market or a strategic approach – or whatever mix of these two approaches – best enhances China's interests, hedging their energy security bets rather than choosing one strategy at the obvious expense of another becomes an attractive strategy to minimize risk.

As with hedging in finance, 'longs' in a hedging strategy are associated with cooperation or positive developments, such as profiting from an upward market or preventing crisis. 'Shorts' are tied to strategic and security considerations. That is, insuring against the possibility that cooperation will not preserve China's interests or that instability and higher costs of petroleum in the international market will disrupt China's supply security and weaken China's economic growth.

Investors can develop a hedging portfolio whereby it is possible to profit from both 'longs' and 'shorts'. Similarly, China can profit from both its 'long' and 'short' strategies. States often recognize the need to cooperate in dealing with common problems, such as energy security, which stimulates 'long' strategies. For example, China has developed closer ties with the IEA, become an active member of a number of multinational institutions, participated in anti-piracy operations in the Gulf of Aden and is heavily involved in United Nations peace keeping operations in an increasing number of countries. All these efforts can enhance China's energy security. Conversely, should China 'free ride' on the IEA efforts to stabilize world energy markets and other states' efforts to secure sea lanes of communications (SLOCs)? Should China take advantage of sanctions against rough petroleum exporting states or cooperate as a 'responsible stakeholder' with the international community seeking to isolate these states? Additionally, mistrust is difficult to transcend in an anarchical international system, and relative gains are often more important than absolute gains.

China does not entirely trust that the international petroleum market, cooperation or "longs" will safeguard China's energy interests. Instead, China has taken a number of steps to develop "short" strategies that seek to insure against supply disruption, high prices and instability in the international petroleum market. Just like an investor seeking to hedge against a volatile market through derivate products, future contracts and "short" selling, China bets against the international petroleum market or cooperation and has taken out insurance 'outside' the petroleum market and through broader diplomatic and strategic measures.

The government and the NOCs

China's central government has the means to develop and implement hedging strategies – especially when it comes to long-term planning and during crises – through its authority and control of the NOCs.

The central government has several mechanisms for controlling the NOCs: It appoints NOC leaders (the nomenklatura system); sets up party groups with the NOCs; serves as lawmakers, regulators and law-enforcers; collects dividend payments; sets domestic oil product prices; sets taxes; approves NOC investments and credits; and develops overall planning and grant-exploration licenses. The central government cannot control the entire Chinese energy sector, which is growing at an historical record pace, and the NOCs have become powerful actors, especially in their daily businesses and in the pursuit of profit at home and abroad. The government has difficulties overseeing all of the NOC's deals, investments, production, exploration plans and so on. At the same time, controlling all aspects of the NOC's activities is probably not the government's aim, although many Chinese leaders have benefitted from the NOCs.

However, the NOCs' autonomy does not override the central government's authority. Corporate interests cannot undermine the overarching objective of providing for China's oil supply security, which is linked to China's economic growth and tied to domestic stability and the China's Communist Party (CCP)'s legitimacy. The NOCs may have invested in countries without the central leadership's approval; they often sell oil in the international market for profit instead of shipping more oil back to China; they seek to manipulate the domestic downstream market in order to pressure the central government to raise oil product prices and at times their presence in certain countries weakens China's diplomatic status. Nonetheless, the government maintains a number of mechanisms for controlling NOCs and has the authority to instruct the NOCs to provide for China's oil-supply security in times of an emergency or a crisis, which has been facilitated by the hedging strategies developed by the central government.

It has been pointed out that the NOCs are involved in the planning and implementation of the five-year plans and thereby shape strategies and policies according to their own interests (Downs, 2008). Nonetheless, the NOCs were initially reluctant to accept some of the core hedging strategies that have been outlined, such as the decision to develop cross-border pipelines and the build-up of a strategic petroleum reserve (SPR), and they were not the key players driving the ambitions for a large state-owned tanker fleet.

In addition, maintaining the coal sector as the bedrock of China's energy security, emphasising energy efficiency and conservation, and aiming to develop and increase the use of alternative energy, highlighted in various long-term plans, are goals not directly linked to the NOC's interests.

More importantly, whether the five-year plans or the long-term strategies correlate with the NOC's interests is not the core issue. The fact is that roughly all the strategies put forward by the central government and the energy institutions in the early 2000s, which shows a willingness to hedge against and reduce the risk and consequences of oil supply disruption, a sudden price rice and a growing net oil-import gap, have been developed and advanced. This provides evidence that the central government has been a key driver behind China's energy security policy and has successfully implemented a number of hedging strategies, such as: maintaining a strategically favorable energy mix; building an SPR; increasing refinery capacity; investing in long-term future contracts; securing overseas equity oil production; building a large state-owned tanker fleet; developing cross-border pipelines and diversifying China's sources, routes and energy mix. Let us, therefore, examine these hedging strategies in more detail.

Hedging strategies

Despite the recognition that China's growth model is environmentally unfavorable and unsustainable, China's central leadership has emphasized that coal will remain a crucial factor in China's energy security policy. Maintaining a favorable energy mix, whereby roughly 90 percent of China's energy demand is provided for by domestic sources, reflects the continued emphasis on self-sufficiency, but also demonstrates that the central government is willing to pay the cost of insuring against oil supply disruptions and to hedge against the availability of sufficient oil supplies at affordable prices.

In order to hedge against a crisis in the international petroleum market or other emergencies short of a war involving China, measures have been taken to develop an SPR to insure against oil-supply disruption and price volatility. Refinery capacity has been expanded, primarily due to the NOC's profit considerations, but also to enhance China's import flexibility and security of supply by expanding China's ability to refine crude oil from more suppliers.

The NOCs have been profit-driven in their going-abroad strategies since the 1990s. However, the NOC's commercial interests are beneficial and conducive to China's oil-supply security. More importantly, the NOCs' overseas equity investments, production and marketing rights, all provide China with a hedge against risks in the international petroleum market. Having the opportunity and authority to instruct NOCs to ship more of the overseas oil production back home during a crisis in the international petroleum market could allow China to be relatively better off than other major oil consumers during a crisis or war.

This strategy is reinforced by the fact that China has hedged against exceedingly high oil prices in the international market during a crisis or a war in an oil rich region through the build-up of a large, state-owned tanker fleet, which makes it possible to ship China's NOCs overseas oil production back on Chinese tankers with lower freight costs than if China were to rely on chartering international tankers during a crisis. A state-owned tanker fleet also becomes a hedge against disruption in the availability of oil during a crisis, since the central government can force Chinese tankers to operate with high risk in a conflict area in order to access oil terminals, where other shipping companies may not operate. Finally, by having its own tankers and own capacity, China can self-insure and avoid high insurance premiums (Tunsjø, 2013).

These hedging strategies are developed to manage risks in the international petroleum market and not to eliminate threats to China's energy security. For example, China's overseas oil production cannot be protected or shipped back home if China finds itself at war with the United States. Neither can China's tankers and vital sea lanes of communication (SLOC) be safeguarded by the People's Liberation Army Navy (PLAN). Indeed, a state-owned tanker fleet will be counterproductive if China is at war with the United States, since it will be much easier to identify which tankers are carrying oil to China. Accordingly, the distinction between peacetime risks and wartime contingencies is crucial to understanding key aspects of China's energy security policy and how and why China has been hedging.

In addition, the cross border pipelines that China has developed act as a hedge or a 'short' strategy that provides protection if China's reliance on 'longs' or seaborne petroleum supplies and the international oil market is disrupted. Since the security of pipelines and seaborne supply routes differ, and the pipeline 'market' and the international petroleum market remain distinct, in the case of China's energy security pipelines are considered more vulnerable to peacetime risks and safer during wartime threats, while seaborne energy supplies are safer from peacetime risks and more vulnerable during wartime threats. Thus, combining pipeline and seaborne supply routes to hedge against supply disruption strengthens China's risk-management capability.

The development of hedging strategies hinges on whether the Chinese government can control its NOCs and its state-owned tankers in a crisis in the international petroleum market or during a war in an oil-rich region. For example, whether China can use its overseas equity production and state-owned tanker fleet to hedge against the market depends on whether the Chinese government can instruct the NOCs and the shipping companies to work for the domestic market in a crisis in which they could profit much more from selling their equity oil in the international market or charter out their tankers. National interests will override commercial interests during a crisis in which oil prices become exceedingly high or oil supply is interrupted. The Chinese government is unlikely to allow its supply security to be threatened, and it is expected that, in a crisis or emergency, the Chinese state-owned companies, even though they are powerful and at times undermine national interests in their search for profit, will follow instructions from the central government.

It is difficult to point to an example in which the Chinese government has done this in the past, and it can be argued that during the war between the United States and Iraq in 2003 and the subsequent high oil prices, the Chinese government did not take such measures. However, it is important to remember that this was almost 10 years ago and China's net oil import gap has grown considerably since then. Concern with energy security has now become a top priority among China's leaders. In fact, alertness to energy security was partly a result of the events since 9/11, U.S. military presence in Central-Asia and the wars in Afghanistan and Iraq. Energy security has become strategic and part of the government's five-year plans, coordinated at the highest levels and involving an issue area that has been explicitly recognized as of major national security interest.

More important is the fact that there are many examples whereby the government has instructed state-owned companies to operate strategically instead of pursuing their commercial interests. During the electricity shortage and rising coal prices in January 2008, the Chinese government was willing to use its authority to ensure adequate energy supplies. As state media described the crisis as China's worst-ever power shortage, it was reported that the government 'put in place a two-month ban on coal exports'. The Ministry of Communication stated that 'all thermal coal exports will be suspended. Where there is need, all international shipping capacity will be diverted for domestic transportation requirements (SeaTrade Asia, 2008)'.

There is no secret that the NOCs have been running huge losses in the downstream sector in China because domestic prices are set by the government. Platts, a leading industry information provider, reported in April 2011 after a sharp rise in oil prices due to turmoil in a number of Arab countries that 'Chinese state oil majors have had to increase production of petroleum products in recent weeks, probably by directive of the central government, to fill a big gap in supply resulting from drastic cutbacks by private refiners in East China, where operations have been cut to as low as 30 percent of capacity due to dismal margins (EnergyAsia, 2011).'

Sudan and Iran are other examples where Chinese corporate and national interests have clashed and where the Chinese government probably instructed the NOCs so that broader strategic and national interests were not undermined (Tunsjø, 2010, 2013). As the international community began to highlight the atrocities and humanitarian disaster centred on the Darfur region of Sudan in 2007, China hedged its bets and initiated subtle adjustments to its Sudan policy. The Chinese government showed an interest in not letting its strategic and corporate interests in Sudan undermine broader national interests, and demonstrated willingness to avoid opportunity losses from its involvement in Sudan. China balanced its strategic and corporate interests in Sudan with a hedging policy that recognized that 'more than energy is at stake' (ICG, 2008; Jakobsen and Zha, 2006, p. 67).

The Chinese government seemed unwilling to undermine its international reputation by protecting limited energy interests in a discredited regime. Indeed, China was facing diplomatic risk and undermining its international status by shielding Sudan from UN Security Council (UNSC) resolutions. But as witnessed by the diplomatic and political steps taken in 2007, China manoeuvred into a position whereby it could put pressure on the Sudanese government to accept a UN/AU hybrid peacekeeping force, thereby improving China's diplomatic standing, and simultaneously maintaining existing ties with the Sudanese government, thereby safeguarding Chinese strategic and corporate interests in Sudan. Through its diplomatic initiatives, which showed a transition from being reactive and defensive to becoming proactive and offensive, China enhanced its diplomatic standing and reinforced the perception that China is a valuable diplomatic player in finding settlements to regional crises on a global level.

The Chinese government showed a commitment to not letting corporate interests determine national interests (ICG, 2008). In other words, China's diplomatic steps in 2007 indicate a willingness to balance its hedging strategy by 'buying' more 'longs' (China becomes a responsible player in international affairs and cultivates a market approach to energy security) in order to offset 'shorts' (detrimental effects of a strategic approach to secure energy supplies).

Regardless of Chinese NOCs investing and committing to large investments in Iran's hydrocarbon sector, notwithstanding the business opportunities Iran offers and despite the fact that Iran has been a major supplier of Chinese crude oil imports, China has supported four rounds of UNSC sanctions against Iran. In assessing the relationship between security and profit in China's energy security policy, it is interesting to note that Iranian oil exports to China dropped significantly in the first half of 2010. Compared with the same period in 2009, China cut its imports of Iranian crude oil by 31.23 percent (Platts, 2010; Hussain, 2010). Platts reported that traders in Asia 'attributed the drop in imports from Iran to relatively higher Iranian official selling prices compared with rival Middle East grades and said the reduction had little to do with sanctions' (Platts, 2010).

Other commodity-market analysts, such as Edward Morse, head of commodity research at Credit Suisse, finds this puzzling given the fact that China's import needs and demand increased considerably in the first half of 2010 (BBC, 2010; Morse 2010). Indeed, Iran was the only country among China's top-ten suppliers that saw its exports to China fall in the first six months of 2010 (Hussain, 2010; Platts, 2010). This, then, requires more of an explanation. One important aspect is the potential linkage between deliberations for new and tougher sanctions against Iran, the pressure on China from the United States, EU and a number of Arab states to support sanctions on Iran and the noteworthy drop in Iranian crude oil exports to China in the first half of 2010.

In short, as the United States pushed to secure international support for harsh sanctions on Iran in the spring of 2010, China's commercial interests in Iran became subjugated to broader foreign-policy priorities. Maintaining a good relationship with Washington, but also with Arab states such as Saudi-Arabia, is a top priority in Beijing, and China therefore hedged its bets. With the United States and the EU again threatening Iran with sanctions, it was reported in early 2012 that China again had reduced its oil imports from Iran (Bradsher and Krauss, 2012). Price disputes were likely a major factor (Chen, 2012), but as the pattern repeats itself, strategic and security considerations are likely to play an important part.

China has also been hedging through the development of cross-border pipelines that are not necessary economically and commercially viable in a cost-benefit analysis, but act as a hedge or a short-selling strategy that provides protection if China's reliance on 'longs' or the international petroleum market and seaborne petroleum supplies are disrupted. Finally, the build-up of strategic petroleum reserves (SPR), the development of refineries that can process more crude oil from around the world, the reliance on future and long-term contracts, the maintaining of favorable energy mix, and the emphasis on conservation, alternative energy and energy efficiency – these are all additional hedging strategies that insure against supply disruption and enhance China's ability to manage its growing net oil import gap.

Clearly, the central government has the authority in a crisis to instruct the Chinese state-owned companies and prioritize national interests over commercial interests. Accordingly, the saying among many energy experts, that China's energy security policy is characterized by 'weak government and strong companies', does not refer to authority. Moreover, there is evidence to suggest that the Chinese government is probably thinking in hedging terms if we look at the five-year plans developed since 2001 and a number of other strategies developed by the central government.

Astonishingly, almost all of the strategies put forward by the government and the energy institutions in early 2000 have been advanced and implemented. For example: China has diversified its oil imports and invested in large pipeline projects; China has built three flagship oil companies that operate worldwide and has started building an SPR; China has improved energy efficiency and conservation and is a major investor in alternative and renewable energy; China has diversified its energy mix and increased the usage of natural gas and nuclear energy, has pursued an active energy diplomacy, hedged against price risk by adopting future contracts; and has built a large state-owned tanker fleet.

It is important to remember that in less than 20 years China has gone from being a net oil exporter to becoming the world's largest net oil importer. Despite these tremendous changes, China's central government has been successful in carrying out most of its long-term energy strategies. It has addressed many of the challenges to China's energy security identified since the early 2000s and improved China's risk-management capacity through a number of hedging strategies.

Implications

There are several implications of China's energy security hedging strategies and policies that combine security and profit considerations. China's powerful NOCs play an increasingly influential role and are becoming strong competitors in the international petroleum market. Backed by the Chinese government and Chinese banks, the NOCs will continue to seek out investments, M&A and loan-for-oil deals worldwide. Regardless of whether the NOCs develop into hybrid oil companies or resemble the IOCs, at the end of the day they will be controlled by the central government and serve China's national interests when China's leaders call upon them. This can have direct implications for the international oil market.

The international oil market is akin to a large pool of oil. If China's NOCs were to ship all their oil back home, then China would buy less elsewhere, which means there is more oil available to all other consumers. 'So if you take less out of this end of the pool, you can take more out of that end', argues Herberg (2007). However, if the equity oil of China's NOCs, which is normally sold in the international petroleum market for profit, were shipped home during a crisis or war in an oil-rich region, and replaces, for example, disrupted Iranian oil that China normally imports, then there will be less oil available for other consumers.[3] Such a 'lock up' scenario is only likely to occur when China hedges against supply disruption in the international market in a crisis and a war not directly involving China. During 'normal' market conditions, the NOCs will be in the driving seat and a large percentage of the overseas oil production will be sold locally or in the international market for profit, while a wartime scenario involving China will make it difficult to ship equity oil back home.

Oil will be available in the market during a war or a crisis, but probably at an exceedingly high price. China can be reasonably well off compared to other major oil importers during such a situation as Chinese leaders can call on its state-owned tankers to ship oil back to China and self-insure its state-owned tankers operating in a conflict area. Again, this affects the petroleum and tanker market, as some of the Chinese tankers that normally are chartered out in the tanker market will be instructed to serve China's interests, while some of the remaining tankers in the world tanker fleet may be reluctant to enter a conflict area or be unable to insure their tankers, thereby limiting tanker capacity and driving up freight rates. This situation is likely to be reinforced in the years ahead as China's state-owned tankers can be expected to gain a more prominent position in the tanker market, both as a result of the tanker build-up and the fact that government-backed state-owned tankers are more likely to survive the current bearish and difficult tanker market.

The global search for petroleum-investment opportunities and oil production deals by China's NOCs, gives both the NOCs and China a more prominent role in the petroleum market and world affairs. The Chinese government, banks and the PLA have often facilitated the NOCs' going-abroad strategy through a number of sweeteners, including diplomatic support, loans to host countries and arms deals. When the NOCs have operated more or less as autonomous actors, this affects China's diplomatic, strategic, political, economic, military or security interests. China's energy security policy and the activities of the NOCs signal that the NOCs have become more important actors in China's domestic policymaking apparatus and in the international energy market, while China has developed a broader portfolio of energy interests that needs to be safeguarded internationally, which will push China toward a more active role in international affairs.

This corresponds with a general trend whereby China's interests tend to expand as its power increases. A more dominating China acquires a stronger stake in the world order as its interests are spread throughout the world. Simultaneously, as China expands its worldwide interests, these need to be protected. However, this is a delicate and sensitive task. More Chinese military power, intervention, policing, diplomatic engagement, assertiveness and influence could trigger security dilemmas, counterbalancing, arms races and containment of China. More involvement often leads to further engagement and expansion and this, in turn, produces new areas or interests that need to be protected (Jervis, 2003, pp. 381–82).

China's growing involvement in UN Peacekeeping Operations (UNPKO), its participation in constabulary tasks and patrolling of SLOCs, its shifting but cautious stance on sovereignty, and its delicate balance between developing war-fighting access-denial platforms and more power-projection capabilities, show how China's growing global energy interests are shaping broader Chinese foreign, security and defence policy.

Commensurate with China's rising power is also its growing importance in international energy institutions, and these institutions' and organizations' recognition that cooperation with China is of critical importance. China is also becoming more involved in Arctic affairs and seeks to shape this new energy frontier according to its interests.

Finally, great-power relations will be crucial in promoting cooperation and managing conflict of interest related to energy security. China and the United States interact globally on energy-related questions. The United States remains the key security guarantor for the Middle East, while China's presence in the region is growing. China is expected to increase its dependence on Middle Eastern oil in the future. U.S. naval supremacy and control of SLOCs, which are vital to China's trade and oil import, are causing concern in China. China's naval ambitions and growing presence in far-distant waters are bound to alarm policy-makers in the United States. The challenges are profound, and energy security can pull the United States and China closer together through their interdependence as the world's largest oil consumers, or it can fuel rivalry and conflicts of interest.

China–Russia relations are facing a number of challenges. Their common interest in challenging the United States and its presence in Asia is eroding as the United States withdraws most of its troops from the Asian mainland. Instead, China has become the dominant power on the Asian mainland, and Russia is falling into a junior position in their bilateral relationship. From 2005 until 2011, China only bought a fraction of its arms from Russia (Jakobson et al., 2011). While there remains several obstacles in improving Sino-Russian energy relations, such as: uncertainty about Russian petroleum reserves in Eastern Siberia; the lack of Russian infrastructure in Siberia and the Far East; the difficult investment conditions in the Russian petroleum sector; and disputes about contracts and prices; energy ties are one of the issues that can potentially revitalize the strategic partnership between the world's leading petroleum supplier and consumer.[4]

Conclusions

The potential disruption of oil supplies to China will remain a risk that China manages through hedging. Examining China's energy security based on a hedging framework shifts the analysis from wartime threats to peacetime risks, from securing to insuring adequate oil supply, and from controlling to managing disruptions of SLOCs.

Contrary to conventional and popular wisdom that emphasizes the so-called 'Malacca Dilemma' in China's energy security thinking, China is not vulnerable to interruptions in its seaborne oil supply short of a major war with one or a coalition of major powers. In short, a distant blockade would not stop supplies of oil to China because of market mechanisms, and the fact that ownership of oil on tankers shifts hands a dozen times at sea; a close blockade would be dangerously escalatory and potentially undermine the limited objectives of any blockade; a blockade by convoy would logistically and operationally overwhelm the blockading states, including the powerful U.S. navy; and precision strikes on Chinese oil installations and infrastructure would be unthinkable short of total war. In addition, seaborne oil imports constitute less than 10 percent of China's total energy mix. This suggests that China will be able to withstand a blockade that normally takes years to have an effect. Accordingly, 'it is difficult to imagine a limited-war scenario that would justify such actions by any blockading nation' (Collins and Murray, 2008).

If, China and the United States find themselves at war, then China's oil supply is likely to be disrupted, and there is little China can do to prevent such an outcome. China might receive imported oil through cross-border pipelines, but these do not have the capacity to compensate for the blockade of seaborne oil supplies. However, China has enough domestic energy resources to sustain its military operations and critical infrastructure. Accordingly, instead of preoccupying our analysis of China's energy security with the threat of war, it is more useful to examine peacetime risks to China's petroleum-supply security, which can have a negative effect on economic growth and trigger social instability. By examining peacetime dangers, such as piracy, terrorist attacks, environmental disasters and even a war in an oil-rich region, it becomes clear that these issues are manageable and that China has successfully developed hedging strategies to minimize these risks.

Notes

1. The argument developed in this chapter draws especially on Tunsjø (2013) and also Tunsjø (2008, 2010).New deals are reported continuously, which indicates that the $137 billion is too low. In April 2011, China Development Bank signed a deal to lend Turkmenistan 4.1 billion to develop a strategic partnership with Central-Asia's largest gas producer.
2. Leading Chinese energy security experts emphasized the importance of market mechanisms at the conference *Energy Security in Asia*, Beijing May 21–22, 2009, which the author co-organized.
3. An even worse example for a number of European countries, Japan and to some extent the United States would be if a war or turmoil/uprising occurs in Saudi Arabia, which is China's leading supplier. This would lead to a major disruption of oil supplies in the international market, which could be reinforced if China decided to ship all or as much as possible of its equity or marketing-right oil back home. In addition, China's oil trade with Iran, a country shunned by Western states, could boost the fact that China would be relatively better off than other major oil importers.
4. China's president, Xi Jinping, visited Moscow on his first trip abroad in March 2013. The signing of new energy deals were an important outcome of the meeting between Xi and President Putin. China's and Russia's decision to veto a resolution on Syria in the UN Security Council in early February 2012 could be another attempt to revitalize the Sino-Russian strategic partnership.

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6

The Norwegian Energy Security Debate: Domestic and International Dimensions

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The main goal of this chapter is to present recent developments in the Norwegian debate on energy security and to place this debate in a broader historical and geographical context. There are several factors making the study of the Norwegian debate on energy security an interesting undertaking.

First, Norway is one of the major producers and exporters of energy globally. Norwegian views on energy security and the way they are translated into political actions have therefore bearing not only on developments in Norway but also on developments in regional and global energy markets.

Second, Norway is to a very large extent unique in the sense that the hydrocarbons produced are mostly exported, while the domestic energy needs are met by renewable resources, mostly hydropower. This specific structure of the Norwegian energy mix makes Norway especially vulnerable to global market trends and to climatic conditions at the local level, which is also partly reflected in the Norwegian debate on energy security.

Third, Norway is one the few countries that have managed to cope with tensions caused by what is sometimes referred to as ‘the oil curse’. The way Norwegian authorities have chosen to approach development of the country’s energy sector occupies also a prominent place in the Norwegian debate on energy security, in which one of the key concerns has been the fear of how exploitation of huge oil and gas deposits may influence social, political and economic development of the country.

Last, but not least, having in mind Norway’s global and regional position as an energy supplier and the role of the energy sector in the country’s economy, it is important to remember that there are two sides to the energy security debate in Norway. On the one hand, there is a focus on the energy security of the country and its citizens, understood here as providing sufficient energy at reasonable prices; but on the other hand there is also a clearly visible concern for security of energy, understood here as the need to provide secure and safe framework conditions for the development of the domestic energy sector and its international activities.

In order to explore all aspects of the Norwegian debate on energy security, this chapter is divided into several parts. In the first part various general approaches to energy security are presented. This part is followed by a brief presentation of main trends shaping Norwegian energy policy and the debate on energy security. In the next part the issue of agency in this debate is dealt with, and we present the whole spectrum of actors involved in energy policy-making in Norway. The goal here is to identify key actors who shape the debate and design and implement energy policy in Norway. In the next part the focus is on the domestic and international dimension of the Norwegian debate on energy security.

Special attention is being paid to what could be termed Norwegian structural energy challenges. Those challenges include the questions of domestic security of supply and the need to promote sustainable development. Also discussed in this part is the question of Norway's international role as an important energy supplier and how it is understood in Norway in the context of the debate on energy security. In the last part of the chapter we sum up our findings and present some conclusions on the current state of the Norwegian debate on energy security and potential future developments in that field, providing some answers but also asking some new and highly relevant questions about old and new challenges Norwegian policymakers will have to address.

It seems that over the last decades we have seen an increasing convergence of Norway's domestic and international energy concerns and interests. The Norwegian energy market and, to an even greater degree, Norwegian energy interests abroad are being influenced by international developments and by global trends that shape the framework conditions in which Norway's energy policy is being designed and implemented. Although special in many energy respects as both a global power in hydropower and a key international fossil-fuel player, Norway is not immune to what happens in other parts of the world and has to cope with some specific energy security-related challenges to which not only domestic but also international solutions are needed. How Norway copes with the domestic and international energy–security-related challenges and the impact of domestic and international factors on the process of energy policy shaping and implementation is the main topic of this chapter.

The concept of energy security

In order to understand why some topics have made it to the top of the energy security debate in Norway we have to start by presenting our operational definition of energy security and see how the specific features of the Norwegian energy mix may have influenced that debate.

There are various approaches to energy security and definitions. In their 2005 book *Energy and Security* (Kalicki and Goldwyn, 2005), on the link between energy and security, the team of contributing authors focused on both geographical and thematic aspects of energy security, and the editors called for a closer integration of the study of energy and foreign policy. The topics discussed included: energy security and markets; the role of Organization of the Petroleum Exporting Countries (OPEC) and the International Energy Agency (IEA); studies of spatial aspects of energy security with the focus on Russia, Eurasia, the Caspian Sea region, the Middle East and Africa, Saudi Arabia, Iraq and the Gulf; and also the role of the Pacific Rim, China and Northeast Asia and the Asia-Pacific Economic Cooperation (APEC) approach to energy security; the questions of energy security in the North Atlantic, American and North Sea context; the reform of the gas market; a new energy security strategy in the United States; the link between technology development and energy security; as well as questions of governance, transparency, and sustainable development, the challenge of climate protection, the question of strategic energy reserves and evolution of the global gas market.

A similar multifaceted approach was proposed in a joint study presented in Davos in 2006 (World Economic Forum, 2006). In that study energy security is described as an umbrella term that covers many concerns linking energy, economic growth and political power. According to that study various actors in the energy game have specific foci when it comes to energy security. Consumers and energy-intensive industries desire reasonably priced energy on demand and worry about disruptions. For energy-producing countries, security of revenue and of demand are integral parts of any energy security discussion. From the point of view of energy companies the question of access to new reserves, ability to develop new infrastructure and stable investment regimes are critical. Developing countries, in turn, are most concerned about the ability to pay for resources they need to drive their economies, and they may fear balance-of-payment shocks. For national policy-makers the main concerns are risks of supply disruption and the security of critical energy infrastructure that can be destroyed by terrorists, by war or by natural disaster.

In one of the newest and most comprehensive analyses (Sovacool, 2010a) a team of authors focused on a number of issues, such as: the link between energy security and climate change; the sustainable development and energy security; the maritime dimension of energy security; the public-policy dimension of energy security; the diversification dimension; the environmental dimension of energy security; the question of energy poverty; the link between social development and energy security; the role of energy efficiency in addressing energy-security-related challenges; the question of the energy services; the link between industrial development and energy security and, last but not least, various ways of understanding and measuring energy security and energy security vulnerability of various actors.

In the introduction to this volume, Sovacool (2010b) presented no less than 45 definitions of energy security formulated by various authors and tried to find common denominators. In his view there are four key criteria of energy security: availability, affordability, energy efficiency and stewardship. Availability relates to the relative independence of and diversification of energy fuels and services; affordability means not just lower, but also stable, prices, and equitable access to energy services. Efficiency has to do with improved performance and deployment of more efficient energy equipment and changes in behavior. Stewardship, in turn, focuses on the question of sustainability, ensuring that energy systems are socially acceptable and not harmful to the environment (Sovacool, 2010b, pp. 10–11).

How can those four criteria be used to measure the situation in the area of energy security in Norway by 2014? Before applying those four criteria to measure the level of energy security in Norway it is important to look at the specific features of the Norwegian energy system and at how the issues of energy security have been framed in the official Norwegian debate on energy.

Norway as an energy actor – a brief introduction

Over the last four decades Norway has developed from a 'normal' Western importer of hydrocarbons to one of the key suppliers of energy to Europe. In 1972 Norway produced 7.7 mtoe of energy, which was slightly more than 50 percent of the country's total primary energy supply (TPES). In 1975 production of energy in Norway was for the first time in recent history higher than consumption, the first reaching 16.1 mtoe and the latter 14.6 mtoe. In 1980 production of energy in Norway crossed the 50 mtoe line, the 100 mtoe line was crossed in 1989, 150 mtoe in 1993 and in 1996 total production of energy crossed the 200 mtoe line. Norwegian energy production reached its peak in 2003 with a production of 233.1 mtoe, and since 2003 production has been falling. The fall was especially dramatic for oil production, which peaked in 2001 at 162.6 million tons, but by 2011 was down to 93.4 million tons. The increased production of gas, which reached 106.4 billion cubic meters (bcm) in 2010 (SSB, 2012) and fell to 101.4 bcm in 2011, has not been able to replace the dwindling oil production. When it comes to energy consumption it was only in 2008 that the Norwegian TPES climbed above 30 mtoe; in the same year total energy production was still above 200 mtoe (211.5 mtoe) (OECD, 2011).

The above data illustrate that Norway's role in the energy world has taken a dramatic turn. To start with, Norway was a small energy producer entering the global and regional energy game after the discovery of deposits of hydrocarbons on the Norwegian continental shelf (NCS) in 1969. Norway exported small volumes of oil already in 1971, but it was only in 1976 that exports exceeded 10 million tons (13.6 million tons). Oil exports grew until 2001 when 141.9 million tons were exported and have been falling ever since, to 68.3 million in 2011. Gas exports started in 1977 when 2.6 bcm of gas were exported and had been growing continuously, reaching 97.3 bcm in 2010 until falling to 94.9 bcm in 2011, which was the first drop in exports since 1993.[1]

Until 2010 Norway was the world's second-largest exporter of gas, but in 2011 lost this position to Qatar. Norway exports more than 95 percent of its gas. According to BP (2012) gas exports reached 96.8 bcm in 2011, of which 92.8 bcm entered European markets through a network of pipelines, and 4 bcm were sent as LNG to European markets (2.6 bcm), the United States (0.5 bcm) and Asia (0.9 bcm). The biggest importers of gas from Norway in 2011 were Germany (28.4 bcm), the United Kingdom (21.7 bcm) and France (14.7 bcm), followed by the Netherlands (7.4 bcm), Belgium (5.9 bcm), Italy (5.9 bcm), the Czech Republic (3.9 bcm) and Austria and Spain (2.5 bcm each). According to official Norwegian statistics (OED, 2012d, p. 46) 92.5 percent of the gas (97.3 bcm) was exported through pipelines and 4.7 percent as LNG, and the geography of the gas export looked slightly different: British companies imported 27.3 percent of gas; German, 24.5 percent; French, 12 percent; Dutch, 11 percent; Italian 6.4 percent and the rest went to other buyers.

More than 80 percent of Norwegian crude oil is also exported, and the main recipients in 2011 were: the United Kingdom (36 percent of total production), the Netherlands (14.3 percent), France (7.9 percent), Sweden (4.5 percent), Germany (3.6 percent) and the United States (2.9 percent) (OED, 2012d, p. 41).

According to Norwegian energy-production data from the last pre-crisis year – 2007 – oil represented 57 percent, gas 36 percent, renewables 6 percent and solid fuels 1 percent. A very specific feature of the Norwegian energy mix is the fact that 99 percent of all electricity produced and consumed in Norway is based on hydropower. As a consequence, renewables – almost exclusively hydropower – represent 45, oil 35, gas 17 and solid fuels 3 percent of gross inland energy consumption in Norway.[2]

Another specific and exceptional feature of Norway is that it exports almost eight times more energy than it consumes, and that production and export of energy commodities has resulted in a financial bonanza: according to official data, oil and gas exports generated more than NOK6,490 billion in revenue between 1977 and 2011.[3]

All those factors and some others have had a huge impact on the content of the Norwegian debate on energy security. Before presenting the main elements of that debate it would, however, be interesting to see who has been setting the energy – and energy security – agenda during this period of energy prosperity.

Energy policy actors: domestic and external

To understand who have been the actors influencing the Norwegian debate on energy and energy security since the beginning of the oil and gas boom, one has to look at the political developments, at the list of those actors who have been directly involved in implementation of that policy, and those who have various types of stakes in the Norwegian energy sector.

The issue of political and institutional control over the development of the energy sector in Norway was solved relatively early in the process. Facing the new situation after the discovery of huge deposits of oil and gas, the Norwegian political class had to start learning how to manage its new energy resources and how to transform Norway into an important global and regional energy player and one of the key exporters of energy commodities.

The response of the Norwegian political class to that new challenge was the 1971 announcement of what later became known as the ten Norwegian oil commandments, a document providing strategic guidelines for the development of the country's energy sector. According to these guidelines there was a need for national supervision and control of all operations on the NCS; petroleum discoveries had to be exploited in a way which would make Norway independent of others for its supplies of crude oil; new industry was to be developed on the basis of petroleum; the development of an oil industry had to take account of existing industrial activities and the protection of nature and the environment; flaring of exploitable gas should not be accepted; petroleum from the NCS had to be, with some exceptions, landed in Norway; the state had to be involved at all levels and contribute to a coordination of Norwegian interests in Norway's petroleum industry; a state oil company was to be established to look after the government's commercial interests and pursue appropriate collaboration with domestic and foreign oil interests; a pattern of activities must be selected north of the 62nd parallel, which reflects the special socio-political conditions prevailing in that part of the country; Norwegian foreign policy could face new tasks due to the development of Norway's petroleum sector (OED, 2011).

The adoption of that set of rules and their mostly successful implementation have been made possible partly due to the previous Norwegian experience with the development of domestic hydropower energy resources under strict state control based on the principle of the right of reversion (NOU, 2004). Also Norway's mature political culture and consolidated democracy have been factors reducing possible negative impacts of the revenues generated by exploitation of hydrocarbons on the development of the country. As a result Norwegian authorities and the political class adopted a reasonably market-friendly and tax-based approach to the management of oil resources and secured state control of the petroleum deposits on the Norwegian continental shelf and of the rent from oil and gas to the Norwegian people (Gylfason, 2011).

As Table 6.1 shows, political control over the development of the energy sector has, for most of the time since 1978 – the year the Norwegian Ministry of Petroleum and Energy was created – been in the hands of governments dominated by the Labour Party (1978–81, 1986–9, 1990–7, 2000–1, 2005–13), while governments dominated or supported by the Conservative Party have been in charge for shorter periods (1981–6, 1989–90, 1997–2000, 2001–5, and from 2013 onwards).

However, in addition to the political parties that have had the overall political responsibility for the development of the country's energy sector, there are also a number of other national and international stakeholders whose interests and actions have played a part in shaping Norwegian energy policy.

A good illustration of who those stakeholders are could be found in the final report of the Commission for Assessment of the energy and power balance in Norway until 2030 and 2050; the commission was appointed on 4 March 2011 and led by Olav Akselsen, former minister of oil and energy in the Stoltenberg I government and director general of shipping and navigation. The commission presented its final study in 2012 as *Energiutredningen – verdiskaping, forsyningssikkerhet og miljø (Study on energy – value creation, security of supply and environment)* (OED, 2012a). The purpose of the study was to provide a better understanding of the Norwegian energy policy trade-offs. The commission was to examine and evaluate key factors that affect the energy and power balance in Norway, including production, consumption, grid development and power exchange with foreign countries.

In order to fulfil this task the commission entered into a dialogue with 40 organizations and institutions that in the commissioners' opinion had stakes in the Norwegian energy sector, including non-governmental organizations (NGOs) such as Bellona, Naturvernforbundet (The Norwegian Society for the Conservation of Nature), various environmental associations and organizations, professional organizations organizing specialists working on energy related issues, but also Den Norske Turistforeningen (The Norwegian Trekking Association) and Bondelaget (The Norwegian Farmers' Union), which are not obvious candidates for a dialogue on the outlook of the Norwegian energy and power-generation sector (OED, 2012a, pp. 11–12).

An even longer list of stakeholders was presented in the document outlining proposed changes in the Law on Energy published in 2012 (OED, 2012b, pp. 1–2). The list included not only all ministries and local administration bodies, but also trade unions, NGOs, research institutions, professional-interest organizations and the state owned companies.

All those organizations and institutions are not only consulted by state organs on matters of importance, but also take active part in the Norwegian debate on the future of the country's energy sector, presenting diverse

Table 6.1 Political control over energy development – Ministers of Petroleum and Energy and their political affiliations (Labour party-dominated governments in *Italics*, Conservative party-dominated/supported governments in **Bold**).

Minister's Name	***From***	***To***	***Party (Minister)***	***Government***
Bjartmar Gjerde	1978	1980	Ap	*Nordli (Ap)*
Arvid Johanson	1980	1981	Ap	*Nordli (Ap)* *Brundtland I (Ap)*
Vidkunn Hveding	1981	1983	H	**Willoch (H)**
Kåre Kristiansen	1983	1986	KrF	**Willoch (H, KrF, Sp)**
Arne Øien	1986	1989	Ap	*Brundtland II (Ap)*
Eivind Reiten	1989	1990	Sp	**Syse (H, KrF, Sp)**
Finn Kristensen	1990	1993	Ap	*Brundtland III (Ap)*
Finn Kristensen	1993	1993	Ap	*Brundtland III (Ap)*
Jens Stoltenberg	1993	1996	Ap	*Brundtland III (Ap)*
Grete Faremo	1996	1996	Ap	*Jagland (Ap)*
Ranveig Frøiland	1996	1997	Ap	*Jagland (Ap)*
Marit Arnstad	1997	2000	Sp	**Bondevik I (KrF, Sp, V)**
Anne-Enger Lahnstein	1999	1999	Sp	**Bondevik I (KrF, Sp, V)**
Olav Akselsen	2000	2001	Ap	*Stoltenberg I (Ap)*
Einar Steensnæs	2001	2004	KrF	**Bondevik II (KrF, H, V)**
Thorhild Widvey	2004	2005	H	**Bondevik II (KrF, H, V)**
Odd Roger Enoksen	2005	2007	Sp	*Stoltenberg II (Ap, Sp, SV)*
Åslaug Haga	2007	2008	Sp	*Stoltenberg II (Ap, Sp, SV)*
Terje Riis-Johansen	2008	2011	Sp	*Stoltenberg II (Ap, Sp, SV)*
Ola Borten Moe	2011	2013	Sp	*Stoltenberg II (Ap, Sp, SV)*
Tord Lien	2013		FrP	**Solberg (H, FrP)**

Note: SV –Socialist Left Party; Ap – Labour Party; Sp – Centre Party; KrF – Christian Democratic Party; V – Liberal Party; H – Conservative Party; FrP – Progress Party.

opinions on the challenges faced by this important branch of the Norwegian economy.

Some of those actors take part not only in the debate, but also shape this future by their actions. One of the actors most involved in this process is Statoil – a national state-owned oil and gas company. After its merger with Hydro in 2007 Statoil alone generated 9 percent of Norwegian GDP, 13 percent of state revenue and 18 percent of export revenue, which made it an important cornerstone not only of the Norwegian economy but also of the state. According to fresh estimates, the state's petroleum revenues amount to NOK280 billion per year (or almost $50 billion) – NOK165 billion comes from the taxation of companies operating on the Norwegian Continental Shelf (NCS), NOK95 billion is generated through the State's Direct Financial Interest (SDFI), NOK15 billion as the state's share in Statoil's profit through the state's ownership of 67 percent of the shares in the company (Gundersen, 2011).

As most of that impressive revenue is generated through the sales of Norwegian oil and gas abroad, Norwegian energy policy is also influenced by decisions and steps taken by external actors whose actions may impact on the development of Norwegian energy policy and on the debate on energy security in Norway. Some of those actors are direct or indirect competitors on regional and global energy markets. Others are important customers and buyers of Norwegian energy commodities, which makes them important partners and energy-agenda setters whose energy-related decisions may have some impact on the situation of the Norwegian energy sector.

Russia belongs to the first category, as the country competes directly with Norway on the European gas and oil market (see Godzimirski, 2012, 2013; Godzimirski and Demakova, 2012, for more on Russian energy policy). At the same time, the Russian energy sector attracts the attention of many Norwegian energy players, and energy cooperation between Russia and Norway has been defined as strategically important by both Norwegian and Russian policy-makers (Godzimirski, 2007). The now-shelved cooperation between Statoil and Gazprom on the development of the Shtokman gas field may serve as an example of how this strategic cooperation could develop. Also the fact that Statoil in 2012 signed an agreement on strategic cooperation with the Russian state owned oil-company Rosneft may be proof that the cooperation is still viewed as important. On the other hand, some Russian media describe Norway as an important challenger taking shares from Gazprom on the European gas market that for now is completely dominated by Russia and Norway (Panfilova, 2011; Serov and Sarkhnyants, 2013).

In 2009 Norway had a 15.2 percent share of EU oil and 30.7 percent of EU gas imports,[4] and almost 100 percent of Norwegian gas production and more than 75 percent of Norwegian oil production was exported to EU countries (OED, 2012d). Those data combined with the fact that Norway in 1992 decided to join the European Economic Area and in 1994 rejected EU membership makes the EU the most important external actor influencing directly the development of the Norwegian energy sector. There is a clear understanding in Norway that EU regulations – not only in the area of energy policy but also those influencing competition policy, environmental policy, business activities and even foreign and security policy – have some direct bearing on the development of the Norwegian energy sector and its operations, both at home and abroad (NOU, 2012, pp. 546–89).

The three main elements of the EU's official energy policy are security of supply, the impact of energy on sustainable development and, last but not least, the impact that access to and pricing of energy may have on the EU's ability to compete with other global centres of economic power. The very same questions – sustainability, competitiveness and security of supply – also play an important part in shaping Norwegian energy policy. But there is one important difference – Norway being a key producer and exporter of energy commodities is also very preoccupied with the question of security of demand, and especially with the question of security of demand in its most crucial European market.

From approximately 2003–4 onward, Norway has had to operate in a more challenging energy environment, with its own total energy production falling and global energy markets going through a turbulent period, with huge volatility in oil price and insecurity in the global and regional gas markets caused by falling demand for gas in Europe, the shale-gas revolution in the United States and growing competition from LNG producers. Thus, in 2012 Norway faces a situation in which its oil reserves will be depleted in nine years if current production levels are maintained and no new discoveries are made, while gas reserves can be expected to last for another 20 years if production is stabilized at the 2011 level and no new fields are discovered and put into production (BP, 2012). Thus, in a strategic, long-term perspective, the future of the Norwegian energy sector is linked more with gas than with oil, but also with the further development of renewable energy resources.

There are several factors influencing the current Norwegian debate on energy security. The very existence of the hydropower sector playing an important part in securing energy needs, with its specific climate-related challenges, is perhaps the most interesting feature of Norwegian energy policy. As the figure below shows, renewable resources – in the case of Norway almost exclusively hydropower – have over the last four decades represented 35–55 percent of the TPES. This alone makes renewables an important topic in the Norwegian debate on energy and energy security.

Norway is unique in both European and global contexts, as in most developed economies the share of renewables in the TPES is far below 10 percent. Even in the EU, which has an ambition to become a renewable superpower, in 2009 the share of renewable energy in consumption was no higher than 9 percent, although the share of renewables in the EU's domestic production was twice that (18 percent).

In the current debate, this high level of reliance on one specific renewable resource – hydropower – is combined with discussions on issues of concern to energy producers and exporters, actors whose energy security

Figure 6.1 Share of renewables in TPES in Norway (OECD Data)

concerns have much to do with the situation in the global and regional energy markets. In order to understand how these issues have influenced the debate on energy security, we will now look at the domestic and international dimensions of this problem.

Domestic dimension: structural challenges, weather risk-management and security of supply

The huge renewable capacity for electricity production and the high level of dependence on renewable resources have influenced Norway's long-term economic strategy and the debate on energy security. The relatively easy access to non-polluting, renewable sources of energy has also made Norway one of the biggest consumers of electricity per capita. According to the latest IEA global energy survey, electricity consumption reached 23,558 kWh/per capita in 2009 – ten times higher than the world average and almost three times higher than the OECD average.[5] However, this has some disadvantages. As almost half the energy consumed relies on rather unpredictable climatic conditions, the Norwegian society and economy have to cope with the issue of weather risk-management. The Norwegian debate on energy security – especially on security of domestic supply – has a focus completely different from that in most other European countries.

What is debated in Norway is not so much gas- or oil-import dependence, but reservoir capacity and water reservoir levels and the impact this may have on the electricity price and on the affordability of energy.[6] Total reservoir capacity in Norway is 84.3 TWh; in week 33 of 2011 the reservoirs were filled to 77.5 percent (63.4 TWh) of their capacity, while in the same week in 2006 – the year of the most recent serious Norwegian energy crisis – levels reached only 59 percent (or slightly more than 48 TWh). This variation can also be illustrated by pointing to the fact that during one and the same year – 1 January 2011 to 1 January 2012 – reservoir levels reached both their highest and their lowest values for that week since 1998. In the first week of 2011 only 42.8 percent of the reservoir capacity was filled (35 TWh), while one year later 78.2 percent was filled – enough to produce 64.3 TWh of energy.[7]

This dependence on climatic conditions results in huge swings in yearly Norwegian electricity-production levels. According to Norges vassdrags- og energidirektorat (Norwegian Water Resources and Energy Directorate – NVE) data, average production is expected to reach 123.4 TWh, but between 2000 and 2009 it varied between 106.1 TWh in 2003 and 142.3 TWh in 2000 – 126.6 TWh (NVE, 2011, p. 14) constituting the average figure.

In addition to those temporal swings there are also several availability-related challenges that have to be addressed, as some areas have a surplus of production while in others economic development may be hampered by the lack of access to energy. As a way of coping with those structural and spatial challenges a number of thermal power plants were built, but they have played only a limited part in supplying consumers with energy. It was only with the 2009 key installation of the Kårstø gas-driven power plant that thermal power plants could increase their share to even 3.5 percent of the total power supply. In some remote areas of Norway, such as on the Svalbard Archipelago, the whole energy supply is provided by thermal coal- or diesel-driven power plants that, in addition to electricity, also supply heat. However, the use of thermal power plants is rather marginal due to availability of hydropower, the high costs of production and the desire to limit emissions of greenhouse gases. This is a good illustration of how the question of availability is strongly intertwined with the questions of affordability, sustainability and stewardship presented by Sovacool (2010b).

There are several ways of dealing with the structural challenge of energy availability in Norway. On the domestic front the construction of additional grid connections between regions and the extension of the existing grid could be one response. This would help regions with an energy shortage to 'import' energy from parts of Norway with a power-generation surplus. Building new distribution infrastructure in order to create greater power linkages between regions has resulted in a heated discussion on how to find the right balance between energy needs and the need to preserve and protect the local environment (OED, 1998, 2004). The so-called monster-mast debate in the Hardanger area is a good illustration of the above point, as local tensions flared between the interests of energy consumers and those of environmental conservationists organizing demonstrations against plans to build the Sima–Samnanger connection.[8]

However, the most efficient approach to this availability and affordability challenge has been Norway's participation in the Nordic, and then the broader European, cooperation in the power-generation sector, through a system of interconnectors linking Norway's power grid with Sweden, Finland, Denmark, the Netherlands and Russia. This has enabled Norway to import additional energy in periods with lower domestic production and export its surplus in periods when production has exceeded domestic demand. Between 2000 and 2009 Norway had a power-export surplus for six years and had to import more power than it could export for four years (NVE, 2011, p. 68).

In its review of Norwegian energy policy the International Energy Agency (IEA, 2011) commended Norway for the reliable and efficient performance of its electricity sector over the past few years. The study also underlined the impact the Norwegian decision to become part of the regional Nordic wholesale market has had on energy-security-related issues by giving Norway access to what could be viewed as a back-up capacity necessary because of its overdependence on hydropower. Regional cooperation could achieve this because of the complementarity of the energy systems of the involved countries, Norway having the highest share of hydropower, Sweden and Finland being able to provide nuclear back-up capacity and Denmark having its own energy mix with both fossil fuels and an increasingly higher share of wind energy.

The same IEA study (IEA, 2011) also discussed Norway's future role as a possible source of back-up capacity to the North Sea countries, including Germany, the United Kingdom and the Netherlands. Some of these, like Germany with its ambitious *Energiwende*, aiming at increasing the share of renewable energy, look to Norway as a potential 'green battery' that may supply reliable and environmentally sustainable back-up capacity (SRU, 2011). According to this approach, Europe and especially Germany could get access to Norway's pump storage system capacity to compensate for temporary discrepancies between electricity demand and generation on the Continent (SRU, 2011, p. 68). In order to realize those (for the time being) purely theoretical plans, six new cables to the UK, the Netherlands, Germany, Denmark and Sweden, with a total capacity of 6,700 MW would be needed by 2020. These cables could be used for power exports from Norway during consumption peaks and for power imports when consumption is low and when power could be used to pump water back into the reservoirs.

In the opinion of the IEA (2011, p. 8) this would be mutually beneficial. On the one hand it would help European energy consumers that are now becoming ever more dependent on renewable energy resources cope with balance fluctuations in demand and supply, thus enhancing European electricity security; on the other hand it would improve Norwegian electricity security and help Norway manage more efficiently the weather risks that expose 'the country to supply constraints in times of low hydropower availability' (IEA, 2011, p. 8).

The issue of energy cooperation, both Norwegian gas exports and the building of electricity connectors between Norway and Germany, was a central topic discussed during the 2013 visit to Oslo of German Chancellor Angela Merkel (De Rosa and Brekke, 2013). This shows that the solution to Norway's specific energy security concern – availability of energy for domestic consumption in a market that has to manage its weather risk – is becoming more and more dependent on cooperation with other actors. This makes Norway look much more 'normal' in the European and global context, where the international management of energy security risks has been one of the key drivers of energy policy. This development also shows that the boundary between domestic and international dimensions of Norwegian energy policy has become much more blurred than only a few decades ago.

External dimension: security of demand and availability

Since the end of the 1960s the development of Norway's hydrocarbon resources has added a new dimension to the energy security debate. With

Norway becoming a major regional and global energy player, it is not only the question of security of supply to Norwegian energy consumers that has been preoccupying Norwegian policy-makers. As more than 90 percent of hydrocarbons produced in Norway are exported, the external dimension of the Norwegian energy security policy has become an obvious policy concern.[9] The question of security of demand has been the key issue for Norwegian decision-makers ever since the first volumes of Norwegian oil and gas were sent to the export markets.

However, after oil production reached its peak in 2001 the dwindling energy production and the lack of new discoveries that could offset falling production from existing fields have made energy policy-makers worry that Norway was about to lose its key position in the international energy market and made them think about Norway having to start preparing for a post-hydrocarbon era, or as it is put in the Norwegian debate – the life after oil.[10]

Although oil and gas are often produced in the same areas, they are different in market terms. Oil is traded on the global market at exchanges and transported in various ways from production facilities to its final consumers. Although securing a supply of oil is still high on the European and American political agendas, the oil market is functioning rather well and the issue is therefore not heavily securitized and does not pose serious governance-related challenges (Goldthau and Witte, 2010).

The situation is quite different in the European gas market, where there have been several disruptions of supply, and one of the key suppliers – Russia – has often been accused of using its gas supplies to Europe as a political tool. As most of the Norwegian gas is exported to Europe via a 7,800 km long ‘rigid’ pipeline network, Norway has very limited ability to redirect its gas flows to other markets. Since the building and maintenance of this rigid infrastructure has been very costly, Norway, like many other major gas suppliers, wanted to base the trade on long-term commitments and more ‘predictable’ contracts. This provided both exporters and importers with relatively high levels of predictability, helping them to cope with both their security-of-supply and security-of-demand dilemmas. But this system was, at least in the opinion of some buyers, not flexible enough and did not allow for adapting to changing market conditions.

In 2013 the situation on the most important European gas markets was, therefore, about to change as LNG became more competitive, and the shale-gas revolution in the United States had made the North American gas market self-sufficient (Grätz, 2012). This has had consequences for Norway’s position in the European gas market. On the one hand, there has been growing competition for market shares amongst the gas exporters in the shrinking, crisis-ridden European gas market. On the other hand, gas buyers decided to challenge the pricing principles and tried to force exporters to accept new rules of the pricing game. According to the most recent data, in 2011 Norway exported 94.2 bcm of dry gas (piped) and

3.1 million tons of LNG. The share of long-term contracts in trade between Norwegian gas producers and gas customers in Europe was 80 percent in 2011 but, due to recent developments, it was expected that the share would be only 60 percent in 2012 and even lower in years to come as many key gas customers, such as E.ON, have been pressing for linking the gas price with the spot price and with the price of energy produced from other sources and not with the oil price (Arneson, 2012; see also Bertelson, 2012, for impact of other important market factors).

From a Norwegian perspective there definitely was at that time a need to find a balance between securing revenues from the sale of gas and securing market shares in the stagnating European gas market. By accepting new pricing principles, Norway could achieve the goal of securing market shares; but this could be costly not only in economic terms, but also in political terms, as other major gas suppliers could view this approach as a threat to their own economic and political interests (Serov and Sarkhnyants, 2013).

It seems, however, that Norway's ability to increase its market share at the expense of other gas suppliers is rather limited, as the Norwegian resource base probably does not allow for much higher production. Although it is true that in 2011 some new fields were discovered and Norway was the most successful country in 'generating' new additions,[11] that two of four scenarios presented by the Norwegian Petroleum Directorate in 2011 (NPD, 2011) presented a more optimistic vision of Norway's gas and oil future, and that in 2012 Norwegian gas exports reached an impressive 107.6 bcm – 13.4 bcm more than in 2011[12] – it is expected that future production will stabilize at the current level, positive perspectives and recent developments notwithstanding (Helgesen, 2011). This may mean that Norway will not be able to increase its share of European gas imports beyond the current level of 25 percent. When the issue of linking still-undiscovered Norwegian gas fields in the High North with markets in the south was discussed in connection with the publication of the report on the future of gas infrastructure in 2012 (Gassco, 2012), the conclusion was that at the moment it would be premature and unwise to make a decision on building such a costly pipeline (Bertelsen and Endresen, 2012; Njærheim and Anker, 2012). In October 2012 it was also announced that the owners of the Snøhvit license decided to stop work on a possible capacity increase on Melkøya, the main Norwegian LNG plant and the main outlet for Norwegian gas in the region. The key reason was that current gas discoveries did not provide a sufficient basis for further capacity expansion (Dahl, 2012).[13]

The situation could, indeed, change if new discoveries are made further north. In 2013 the NPD presented a new assessment of reserves in the Barents Sea and in other Arctic areas (NPD, 2013) and stated that an approximate increase of 15 percent in the estimates of undiscovered resources on the Norwegian shelf could be expected.[14] Such an addition would indeed strengthen Norway's position as a regional and global energy player and extend the life span of oil and gas production in Norway, but these optimistic estimates need to be verified before any action can be taken. For the time being the lack of available resources seems to be the most important factor shaping the Norwegian discussion on the external dimension of Norwegian energy policy.

Had it not been for this lack of resources, Norway could easily have established itself as the main supplier of energy to Europe because Norway has obviously a number of competitive advantages compared with other actual and potential suppliers of energy to that area. First, Norway shares norms and values with all members of the European Union and is *de facto* a European insider through its 'membership' in the European Economic Area. Second, Norway is a predictable democracy, and cooperation with Norway is therefore not bound with any strategic risks, not least due to the fact that Norwegian policy-makers have been consistently pursuing the policy of non-politicizing their energy supplies. Third, supplies of gas from Norway to Europe do not run the risk of disruption by transit countries, as Norwegian gas reaches Europe directly. Fourth, being a member of the transatlantic alliance Norway shares a strategic vision and concerns with all its European gas customers and is often viewed as a source of politically safe energy. Fifth, Norwegian supplies of gas could be viewed as a more environmentally friendly alternative by those countries which, such as for instance Poland, have to transform their energy mixes and make them comply with the EU vision of a more sustainable energy system as proposed in recent EU regulations and strategic documents.

Conclusions

The Norwegian debate on energy security has two clear dimensions – the domestic and the external. However, with the development of new technologies and both Europe's and Norway's adopting a more comprehensive approach to the issue of energy security, the differences between domestic and external concerns seem to be more and more eroded away. The question of security of supply, closely linked with the question of overcoming structural geographical and economic challenges, and the need to manage weather risks all still dominate the domestic debate, while the issue of security of demand and availability of resources seem to be the dominant topics in the debate on the external dimension of energy security. At the same time, there is a growing realization in Norway that some of the domestic challenges can best be addressed by increasing the scope of international cooperation, while some issues that have traditionally 'belonged' to external energy policy need to be addressed at the domestic level.

When shaping its long-term energy policy Norway has to secure its own energy needs and, simultaneously, as one of the main producers, has an interest in supplying others with substantial volumes of fossil and non-fossil energy. In order to make this policy work Norwegian policy-makers therefore need to understand the relationship between the future demand for energy, the impact of energy conservation on future domestic and external energy needs, the question of energy governance and economic management of energy-related issues, the development of traditional and non-traditional, fossil and non-fossil, energy resources at both regional and global levels, policies of other actors involved in the global and regional energy game, the role of technological breakthroughs in shaping global and regional energy markets, and last, but not least, the question of how various types of legal and political regulations may influence energy markets in years and decades to come.

At the more operational level Norwegian policy-makers will have to deal with three types of uncertainty – *resource uncertainty*, *market uncertainty*¸ and *actor uncertainty*. The issue of resource uncertainty relates to the question of availability of resources and their pricing, which in turn is an important question that is linked with market uncertainty and with Norway's role in various regional and global energy markets. The issue of how regional and global energy markets will develop, what the price of energy commodities and the balance between supply and demand will be are among the most important market-related questions.

Also the question of who the main energy clients will be and with whom Norway will have to compete for market shares will be central in that context. As Norwegian energy resources help other actors meet their own energy needs, the question of Norway's cooperation with those actors is going to be central. What institutional, legal and organizational framework will 'regulate' Norway's energy relations with other energy actors in years to come? Will Norway be able to secure production sites and transport routes and infrastructure on its own or will Norway have to work together with its NATO and EU allies to cope with those issues in a crisis situation? What about the further internationalization of Norway's energy activities? Will building new connectors to Europe make Norway more or less vulnerable security-wise and market-wise? What about the need for the further internationalization of Statoil, in which the Norwegian state is the main stakeholder? Will what happened recently in In Amenas, Algeria – where a group of Islamic terrorists attacked a key gas-production site – have consequences not only for Norwegian energy policy and Statoil's engagement abroad, but also for the way the country defines its security and geopolitical interests and needs? My ambition here has been to provide some answers to the question of what have been the main factors shaping Norwegian energy policy and the Norwegian debate on energy security over the last years, but it seems that while some of the issues have been addressed here, some others will have to be scrutinized in more detail in another study.

Notes

1. Data on exports from http://www.ssb.no/en/yearbook/tab/tab-305.html.
2. http://ec.europa.eu/energy/publications/statistics/doc/2009_Energy_transport_figures.pdf.
3. Calculated by the author based on http://www.ssb.no/en/yearbook/tab/tab-305.html.
4. http://epp.eurostat.ec.europa.eu/statistics_Explained/index.php/Energy_production_and_imports.
5. http://www.iea.org/stats/indicators.asp?COUNTRY_CODE=NO.
6. For more data, see http://www.nve.no/.
7. http://vannmagasinfylling.nve.no/Default.aspx?ViewType=AllYearsTable&Omr=NO.
8. The debate focused on the impact on the local landscape. Some local groups meant that this would do irreparable damage to the landscape and advocated the construction of a land-based cable. This was not accepted by the authorities, mainly due to the very high cost of such a solution. To ease tensions the authorities invited proposals on how to build the planned masts in the most nature-friendly way and to make them 'disappear' in the landscape. For more, see the local activists' webpage at http://stoppkraftlinja.no/index.jsp?pid=5000 and the official presentation of the structural and geographical challenges as presented by NVE and Statnett at http://www.nve.no/PageFiles/9761/06-Statnetts%20scenarier-%20hovedinnhold%20og%20anvendelse.pdf.
9. 'Energy security' is, for instance, mentioned 25 times in the official 2009 account on Norwegian foreign policy, 'oil' is mentioned 217 times, 'gas' 135 times, and 'energy' 365 times (UD, 2009). For more on the link between energy and Norwegian foreign policy, see also Jaffe (2007) and Stern (2007).
10. http://www.regjeringen.no/pages/34819056/hilde_c_b_210512.pdf. See also Skjeldal (2012).
11. http://www.aftenposten.no/meninger/leder/Forlenget-norsk-oljealder-6633039.html.
12. http://www.dn.no/energi/article2539196.ece.
13. http://www.statoil.com/en/NewsAndMedia/News/2012/Pages/02October_Snohvit.aspx.
14. http://www.npd.no/en/news/News/2013/New-resource-figures-for-the-southeastern-Barents-Sea-and-Jan-Mayen/.

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Part II

Renewable Technologies and Politics

7

Technologies for Electricity Generation in Wind Turbines

Bogi Bech Jensen and Tore Undeland

Introduction

The power of wind has been utilized by humans for thousands of years. Wind has been used to propel sailing ships, to mill grain in windmills and, more recently, for electricity production in wind turbines. The first experimental wind turbines for electricity production were installed in the late 1880s. These were not economical and, hence, were not considered a viable alternative to fossil-fuel-powered electricity production.

As concerns for global warming increased in the 1980s, so did the interest in wind turbines. The interest in wind turbines was particularly pronounced in Denmark, where the average annual increase in installed wind capacity was 65 percent in the 1980s. The rest of the world has since followed and the global cumulative installed wind capacity grew exponentially between 1996 and 2010 (see Figure 7.1). The installed wind capacity in 2011 and 2012 did not follow the exponential trend of the previous years, although the global cumulative installed wind capacity grew by 20 percent in 2011 and 19 percent in 2012. The Global Wind Energy Council (GWEC) forecasts that the global cumulative capacity growth rates will be between 13 percent and 14 percent from 2013 to 2017, which would result in a global cumulative wind capacity of 536 GW by 2017 (Global Wind Energy Council, 2012).

This chapter gives an introduction to electricity generation from wind. We present the evolution of wind turbines, noting in particular the size increase over the years. Then we explain the basic theory of extracting energy from wind, followed by a more thorough presentation of different wind turbine drivetrains, including a market review that shows what the dominating manufacturers use in their wind turbines. The chapter is rounded off by looking at possible future technologies for wind turbines.

Evolution of wind turbines

Most commercially available larger wind turbines are horizontal axis upwind turbines with three blades. Horizontal axis refers to the axis that

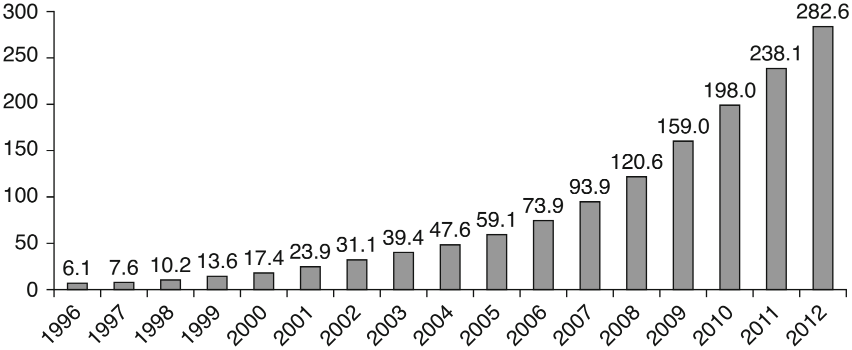

Figure 7.1 Global cumulative installed wind capacity in GW

Source: Global Wind Energy Council (2012).

the blades rotate about and upwind means that the wind meets the blades before it meets the tower.

When generating electricity from wind, the most important performance indicator is cost-of-energy (CoE), which quantifies how much each kWh generated by the wind turbine costs. The CoE has to account for all the expenses of owning and operating the wind turbine and also has to include all the generated electricity. The CoE therefore has to account for the cost of installation (CAPEX), the cost of operation (OPEX) and the produced energy throughout the lifetime of the wind turbine. It is therefore common to annualize the CAPEX and OPEX over the expected lifetime of the turbine and divide this by the expected annual energy production; see Equation 7.1.

$$\text{CoE} = \frac{\text{Annualised CAPEX and OPEX}}{\text{Annual energy production}} \tag{7.1}$$

The annual energy production can be estimated by assuming full production in t_{util} hours. For good wind conditions t_{util} may be 3000 hours, that is a 3MW wind turbine that will provide an annual energy production of 9000 MWh.

The best wind conditions for onshore wind turbines are near the coastline, where the wind is relatively high and steady. The coastline is also very popular for people, which is the reason that it has become increasingly more difficult to obtain planning permission for onshore wind farms. This has led wind farm developers to seek offshore sites, where the wind speeds are even higher and steadier than onshore. However, the cost of installation (CAPEX) and operation (OPEX) are significantly higher offshore than

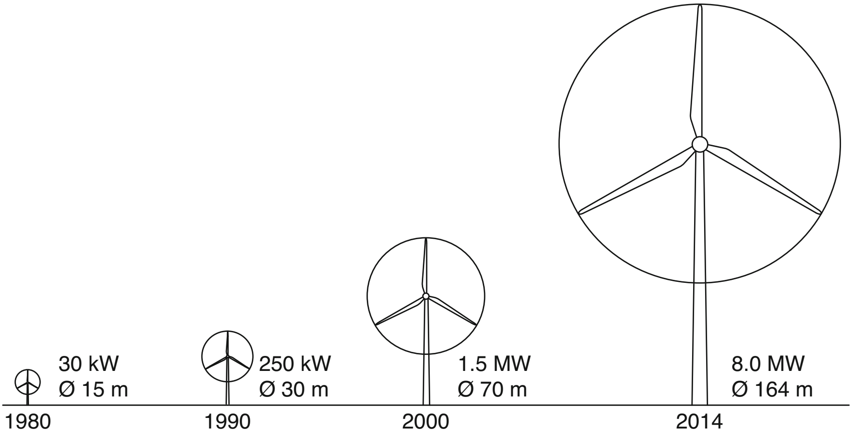

Figure 7.2 Evolution of wind turbine size and rating
Source: Reproduced with permission of Bogi Bech Jensen.

onshore, which has led to higher CoE offshore. If the CAPEX of an offshore wind farm is broken down into its individual elements the wind turbine itself accounts for approximately a third of the total budget. The trend has therefore become to install fewer and larger wind turbines instead of many smaller ones. This has led to the development of very large offshore wind turbines in an effort to reduce the cost of energy from those turbine; see Figure 7.2.

Extracting energy from wind

Kinetic energy in a discrete body is proportional to the mass of the body and the velocity of the body squared. When the body is a continuous flow of air, the mass as a function of time becomes the product of the swept area (A), the mass density (ρ) and the velocity (v) of the flow. The power (P) that a wind turbine can extract from wind is therefore proportional to the swept area (A) of the turbine and the wind velocity (v) cubed; see Equation 7.2. This Equation 7.2 also shows that the extracted power depends on the power coefficient (Cp), which is the ratio between the power extracted from the wind and the available power in the wind. Cp is therefore a number which is less than 100 percent and has a theoretical limit of 59 percent, which is called the Betz limit and expresses the maximum power that an ideal wind turbine can extract from the air flow.

$$P = \frac{1}{2} C_p \rho A v^3 \tag{7.2}$$

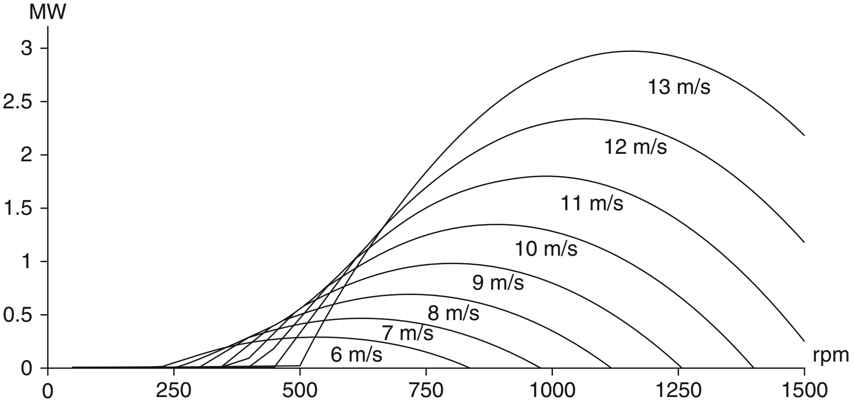

Figure 7.3 Power curves as a function of wind speed and generator rotational speed. MW is mega watts, m/s is meters per second and rpm is revolutions per minute

Source: Reproduced with permission from Bogi Bech Jensen.

The power coefficient is a function of blade pitch angle (β) and tip speed ratio (λ), that is, the ratio between the speed at the tip of the blade and the wind speed. Figure 7.3 shows the power curves as a function of wind speed and generator rotational speed. The figure shows that extraction of maximum power for every wind speed requires variable rotational speed. For example if the wind speed goes from 7 m/s to 12 m/s the rotational speed of the geared generator should go from 600 rpm to 1100 rpm in order to extract maximum power from the wind.

The tip speed ratio is usually controlled at lower wind speeds in order to capture as much wind power as possible. However, this is only possible in variable-speed wind turbines, where the electrical drive train controls the rotor speed as a function of wind speed. This is not possible in constant speed wind turbines, where the rotor speed is constant throughout the entire generation region. Constant speed wind turbines are cheaper and simpler than variable speed wind turbines, but as variable wind turbines capture more wind at low wind speeds these have won favor and have become the norm for larger commercial wind turbines.

Once rated wind speed and above is reached, the turbine blades are pitched out, such that the turbine captures constant rated power from the wind, and the generator and other electrical devices operate at rated power. A wind turbine therefore has two generating regions; see Figure 7.4:

A. Between cut-in and rated wind speeds (usually around 3–5 m/s and 12–14 m/s respectively) the wind turbine power delivery is proportional to the wind speed cubed.

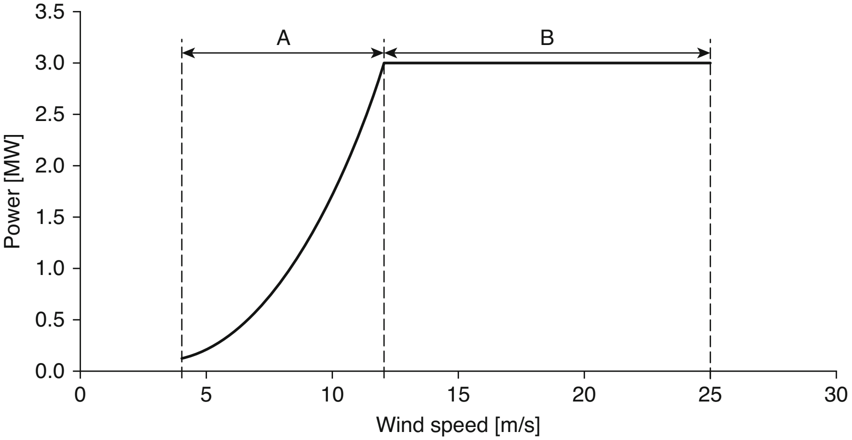

Figure 7.4 Power curve of a wind turbine

Source: Reproduced with permission from Bogi Bech Jensen.

B. From rated wind speed to cut-out (usually around 25 m/s) the wind turbine delivers constant power.

Equation 7.2 also tells us that the only way of increasing the rating of a wind turbine is by increasing the diameter and, hence, the swept area. This is the reason that wind turbines increase in size as the rating increases. However, the increase in diameter is not proportional to the increase in rating but, rather, as a second exponent; see Equation 7.3.

$$P \propto D^2 \tag{7.3}$$

One of the limiting factors in a wind turbine installation is the noise the wind turbine generates. This noise is predominately aerodynamically induced and is therefore a function of the blade tip speed. This speed is kept at 70–80 m/s for onshore installations but can be a little bit higher offshore and might approach 100 m/s. At the same time this means that the rotational speed of a larger wind turbine has to be lower than that of a smaller wind turbine. Typical rotational speeds of a 1 MW wind turbine are in the vicinity of 30 rpm; a 3 MW in the vicinity of 15 rpm; and an 8 MW in the vicinity of 10 rpm.

The lower rotational speed is reflected in the increasing torque of the larger machines. Mechanical power in any rotating system is the product of torque (T) and rotational speed (ω); see Equation 7.4.

$$P = T\omega \tag{7.4}$$

The torque therefore increases more than proportional to the rating of the wind turbine. A 3 MW wind turbine has a torque of 2 MNm, which is similar to the torque at the propeller of a large container ship. The forces at play in a wind turbine standing 100–200 meters tall are therefore enormous and the construction and erection require extreme precision and expertise.

Electricity generation in wind turbines

The rotational movement of the wind turbine rotor is converted to electricity in the generator and is fed to the grid at the desired frequency. The frequency of the electricity from the generator is proportional to its rotational speed which again is a function of the wind speed. As wind speeds are notoriously unstable, the power from a wind turbine is unstable. The unstable supply from a wind turbine can be absorbed in the power system if the portion from wind turbines is small. However, as the integration of wind power increases it becomes more critical to ensure stability in the power system so that services can be delivered to the customers.

Power system operators have developed grid codes to ensure the quality of the power being delivered from wind turbines (Tsili and Papthanassiou, 2009). The grid codes differ from one country to the next, but a common trend is the requirement that wind turbines should stay connected to the grid and support the grid during faults. This is normally referred to as low-voltage ride-through. Additional requirements in more modern grid codes are that wind farms should behave similarly to conventional power stations, which deliver both active (MW) and reactive (Mvar) power for frequency and voltage support in the power system.

Drivetrain topologies

The drivetrain of the wind turbine includes all the components that convert the rotational movement of the rotor into the electricity that is required. There are mainly four different commercially available wind turbine drivetrains.

1. The ‘Danish concept’ drivetrain is for fixed-speed wind turbines. It only includes a gearbox and an induction generator; see Figure 7.5a.
2. The Doubly Fed Induction Generator (DFIG) drivetrain allows for some variable speed and includes gearbox, generator and a partially rated converter, which is connected to the rotor of the generator through slip-rings and brushes; see Figure 7.5b.
3. The full-converter geared drivetrain allows for full variable speed. The drivetrain includes gearbox, generator and a fully rated converter, which converts the electricity from a variable frequency to the desired frequency (50 Hz in Europe and 60 Hz in the United States); see Figure 7.5c.

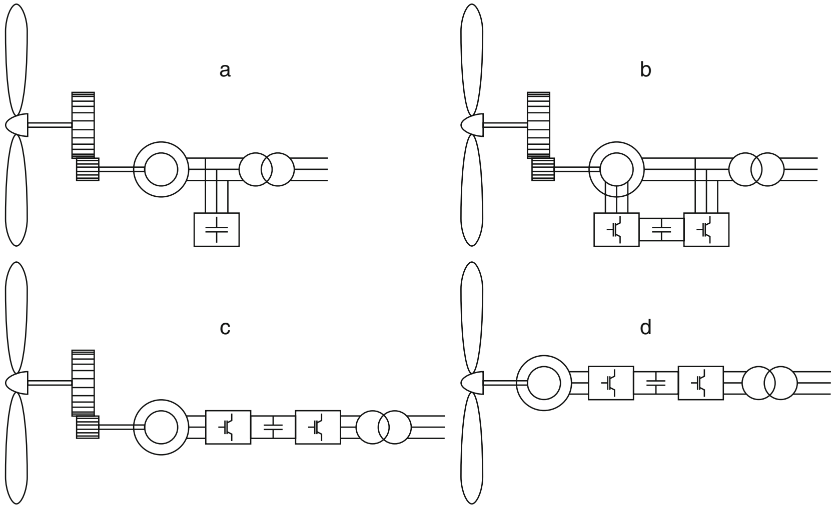

Figure 7.5 Different drivetrain topologies for wind turbines
Source: Reproduced with permission from Bogi Bech Jensen.

4. The full-converter direct-drive drivetrain allows for full variable speed. The drivetrain has no gearbox and only includes generator and a fully rated converter; see Figure 7.5d.

Power electronic converters

Most of the above-mentioned drivetrains include a power electronic converter, which either has full rating (Figure 7.5c, d) or partial rating (Figure 7.5b). A power electronic converter, or just a converter, is a component that converts electrical power from one frequency to another frequency. In addition, sophisticated control method (vector control) allows the converter to control the phase of its output voltage relative to the phase of the connection voltage. This allows the converter to control the speed of the generator and, hence, the wind turbine rotor, which allows for maximum power-point tracking. Maximum power-point tracking ensures that the wind turbine will extract maximum energy from the wind even at low wind speeds. The converter can also control the reactive power delivered to the generator and the reactive power delivered to or absorbed from the grid.

The converter works in such a way that it absorbs the AC power from the generator and turns it into dc power in an AC/DC converter; see Figure 7.6. The power from the generator may have a frequency which is very different from the frequency required by the grid. Once the power is converted to DC

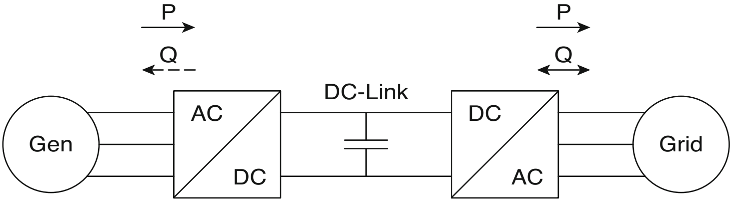

Figure 7.6 Schematic of a power electronic converter
Source: Reproduced with permission from Bogi Bech Jensen.

it is converted back to AC power in a DC/AC converter at the required grid frequency. The generator side of the converter absorbs active power (P) from the generator but may deliver reactive power (Q) to the generator for magnetization of the generator. The grid side of the converter delivers the active power (P) from the generator to the grid and can either absorb or deliver reactive power (Q) to the grid. The reactive power to the grid is controlled according to the required voltage support from the wind turbine.

Another converter variant for wind turbines only has diode rectifiers on the generator side followed by a boost converter. Such topologies are sometimes used with permanent magnet synchronous generators and electrically excited synchronous generators. The advantage of using rectifiers is that they are more efficient and more reliable than the switching devices otherwise used. The disadvantage of using rectifiers is that vector control is not possible and hence the generator is not optimally utilized.

Danish concept

Danish-concept wind turbines are constant-speed wind turbines that employ an induction generator, which is connected directly to the grid. These turbines dominated the market until the end of the last century and in terms of power ratings came up to around 1.5 MW. Danish concept wind turbines typically have a three-stage gearbox and a squirrel-cage induction generator.

The Danish-concept wind turbines are very simple and usually have fixed pitch on the blades. The blades are aerodynamically designed such that the power coefficient drops as the wind speeds exceed rated values. This is normally referred to as stall control and ensures that the wind turbine delivers approximately rated power between rated and cut-out wind speeds.

The clear advantage of these wind turbines is the use of off-the-shelf standard components which result in a cheap wind turbine. The generator is very simple and reliable and there is no power electronic converter.

The disadvantages are multiple. As the generator is a directly coupled induction generator it requires var compensation. This means that the generator has to be magnetized from the grid, and so, although the generator delivers power to the grid in MW it will absorb reactive power in Mvar.

Another disadvantage is the lower average power coefficient and, hence, the lower utilization of the wind turbine.

As Danish concept wind turbines have directly connected squirrel-cage induction generators it is nearly impossible for them to fulfil modern grid codes.

Doubly fed induction generator

The doubly fed induction generators (DFIG) started becoming popular in larger wind turbines in the latter half of the 1990s. DFIGs have a multi-stage gearbox, a wound rotor induction generator and a partially rated power electronic converter. The gearbox can be similar to that in the Danish concept, but the generator is quite different. The wound rotor has three phases with three slip-rings that are connected to the partially rated converter via brushes.

The converter rating is in the order of 30 percent of the wind turbine rating and allows the wind turbine to achieve variable speed from 60 percent to 110 percent of rated speed. Converters were particularly expensive in the late 1990s and early 2000s, which is the reason that this topology only using a partially rated converter and still allowing significant variable speed became very popular. DFIGs are still being installed in large quantities but the reliability issue of brushes, slip-rings and gearboxes, and the challenges of complying with grid codes have resulted in many manufacturers abandoning the concept.

Full-converter geared generators

In a full-converter geared wind turbine the generator is connected to the wind turbine rotor via a gearbox and to the grid via a fully rated converter; see Figure 7.5c. This means that all the power from the wind turbine is converted to dc in the converter and then converted back to AC at the desired frequency.

Once all the power from a wind turbine is fed into the grid via a fully rated converter, the full range of variable speed can be utilized. This allows for best utilization of the wind turbine and because the grid only sees a converter it is possible to both absorb and deliver reactive power. It is therefore easier to comply with modern grid codes when a fully rated converter is employed.

There are predominantly two different generators that are used in such wind turbines: the permanent magnet synchronous generator (PMSG) and the squirrel-cage induction generator (SCIG). The PMSG is a synchronous generator that has permanent magnets on the rotor instead of wound poles. This means that the excitation cannot be controlled and the converter will have to compensate with the required reactive power. As the permanent magnets do not require power to stay magnetized a PMSG will naturally have higher efficiency than an electrically excited generator. The SCIG is the same generator that was used in Danish concept wind turbines and, hence, is a very robust, cheap and well-known machine. The SCIG is electrically excited and the magnetization is delivered from the fully rated generator in the form of reactive power (Mvar).

Reliability of gearboxes has often been brought forth as a clear disadvantage of geared wind turbines. As a result of this some manufacturers have chosen to remove the high-speed gear and instead use a medium speed drivetrain, where the generator has a rotational speed of around 400 rpm instead of 1500 rpm. Medium-speed drivetrains have not been used long in wind turbines but are expected to have higher reliability as the number of stages in the gearbox has been reduced.

Full-converter direct-drive generators

A full-converter direct-drive wind turbine has no gearbox, but the generator is connected directly to the wind turbine rotor. The generator terminals are electrically connected to a fully rated converter. The direct-drive wind turbine therefore behaves electrically in the same way as the full-converter geared wind turbine. There are two commercially available generators for direct-drive wind turbines. The first is the PMG and the second is a wound field electrically excited synchronous generator (EESG). The main motivation for removing the gearbox is to increase the reliability of the wind turbine and, hence, to reduce the CoE. Although this seems as if a less reliable component is removed from the wind turbine, the increased reliability of direct-drive wind turbines has yet to be proven (Arabian-Hoseynabadi et al., 2010).

PMGs in direct-drive wind turbines typically have large numbers of poles, which for a 3 MW wind turbine may exceed 100 poles and for a 6 MW may exceed 150 poles. There are a number of reasons for employing high pole numbers in direct-drive PMGs. The most important reason is that the weight of the generator can be reduced significantly by employing high pole numbers. This is because the flux per pole is inversely proportional to the number of poles and hence the thickness of the rotor and stator coreback is inversely proportional to the number of poles. Additionally as rotational speeds in direct-drive generators are very low, the fundamental frequency is increased by increasing the number of poles. This is favourable for the converter, which otherwise may overheat. The high pole numbers also minimize the risk of demagnetization during faults.

EESGs in direct-drive wind turbines also have large numbers of poles. However, their pole numbers are typically lower than in PMGs. The reason for this is that EESGs are electrically excited and, hence, each pole requires a continuous flow of energy for magnetization. This energy, which is approximately constant for each pole, is lost and, hence, the efficiency of an EESG is reduced as the pole numbers increase. This is not the case for PMG, where the number of poles is determined by the number of magnets placed on the rotor. The EESG on the other hand is free of rare earth materials, which is positive since the price of rare earth materials reached unprecedented heights in 2011. This later proved to be a price bubble, but nonetheless proved the volatility of the rare earth market.

A clear disadvantage of direct-drive wind turbines is the large size of the generators, which are heavy and less efficient than high-speed alternatives. As the gearbox is removed in a direct-drive generator, the entire torque of the wind turbine has to be countered by the electromagnetic torque in the generator. If the generator cannot match the torque of the wind turbine rotor, the wind turbine will accelerate according to Newton's second law. The electromagnetic torque in an electrical machine is proportional to the amount of current in the stator (A); the airgap flux density (Bg); and the volume (V) of the machine; see Equation 7.5. (A) is normally referred to as electric loading or linear current density and expresses how much current the stator is carrying per meter circumference. (V) is actually the volume of a cylinder with a diameter equal to the airgap diameter.

$$T \propto A B_g V \tag{7.5}$$

This means that as the rotational speed in a direct-drive generator is very low, the torque and, hence, the size of the machine has to be large in order to supply the required torque. It also means that if the generator speed is increased the volume and hence weight and cost of the generator can be reduced. As the rotational speed of the wind turbine is limited by noise, the only way of increasing the generator speed is by introducing a gearbox. This introduced additional weight and cost and an additional component that may fail.

Market review

The drivetrain concepts most commonly found in production over the last few decades were described in the previous section. The key distinguishing features can be divided into fixed speed versus variable speed, geared versus direct-drive and full-converter versus partial-converter or no converter.

Table 7.1 shows a market overview from the world's top ten largest wind turbine manufacturers of 2012 (Polinder et al., 2013). The table gives an overview of the transmission – (direct-drive, high-speed geared [HS] and medium-speed geared [MS], the power electronic converter (partial rating, full rating and no converter)), the generator (doubly fed induction generator (DFIG), permanent magnet synchronous generator (PMSG), squirrel-cage induction generator (SCIG) and electrically excited synchronous generator (EESG)), the rotor diameter and the power range.

The fixed-speed Danish concept is no longer installed in modern electricity grids. It is still found in many older wind turbines and is still installed in developing countries. But due to the low utilization of the wind turbine and because the directly coupled squirrel-cage induction generator has

Table 7.1 Wind turbine market overview

Manufacturer	**Transmission**	**Converter**	**Generator**	**Rotor diameter**	**Power range**
General Electric (U.S.)	Geared (HS)	Partial	DFIG	77–120 m	1.5–2.9 MW
	Direct-drive	Full	PMSG	113 m	4.1 MW
Vestas (Denmark)	Geared (HS)	Partial	DFIG	80–100 m	1.8–3 MW
	Geared (MS)	Full	PMSG	112–164 m	1.8–8 MW
Siemens (Germany/ Denmark)	Geared (HS)	Full	SCIG	82–120 m	2.3–3.6 MW
	Direct-drive	Full	PMSG	101–154 m	3–6 MW
Enercon (Germany)	Direct-drive	Full	EESG	48–126 m	0.8–7.5 MW
Suzlon/ REpower (India)	Geared (HS)	No	SCIG	52–88 m	0.6–2.1 MW
	Geared (HS)	Partial	DFIG	95–97 m	2.1 MW
Gamesa (Spain)	Geared (HS)	Partial	DFIG	52–114 m	0.85–2 MW
	Geared (MS)	Full	PMSG	128 m	4.5 MW
Goldwind (China)	Direct-drive	Full	PMSG	70–109 m	1.5–2.5 MW
Guodian United Power (China)	Geared (HS)	Partial	DFIG	77–100 m	1.5–3 MW
	Direct-drive	Full	PMSG	100 m	3 MW
Sinovel (China)	Geared (HS)	Partial	DFIG	60 – 113 m	1.5 – 5 MW
MingYang (China)	Geared (HS)	Partial	DFIG	77 – 83 m	1.5 MW
	Geared (MS)	Full	PMSG	92 – 108 m	2.5 – 3 MW

Source: Developed using data from Polinder et al. (2013).

difficulties meeting modern grid codes, the Danish concept turbines are not found in modern wind farms.

All the variable speed drivetrain concepts have advantages and disadvantages. Because of this, no convergence towards a single winning drivetrain has been seen. Many manufacturers have abandoned the doubly fed induction generator and yet some of the world leaders are pushing it as their premier product. The direct-drive is believed to be more reliable than the high-speed geared alternatives. However, the very large and bulky generators and the extreme usage of rare earth materials in the permanent magnet direct-drive generator are clear disadvantages. Then there is the medium-speed permanent magnet generator, which is less dependent on rare earth materials and should have an acceptable reliability. However, these have not been on the market long and have still to prove their worth.

A few independent drivetrain comparisons have been made (Henriksen and Jensen, 2012; Polinder et al., 2006), but these have not resulted in a clear winner. The evolution of drivetrains is therefore still open and the following section will give an overview of possible future candidates.

Possible future drivetrains

At the same time as the wind turbine manufacturers are going in different drivetrain directions, many more drivetrains are being proposed. This section gives an overview of a few possible future drivetrain candidates and describes their advantages and disadvantages. As they are future candidates, their performance is not clear and, hence, CoE cannot be estimated. The presentation of possible future drivetrains is therefore based on their predicted and expected performance.

Continuous variable transmission

A continuous variable transmission converts the variable speed of the wind turbine rotor to a constant speed at the generator. This means that no power electronic converter is needed, and a conventional electrically excited synchronous generator (EESG) can be employed; see Figure 7.7. EESGs are commonly used in power stations and have clear integration advantages compared to power electronic converters. The converters have a very limited short-circuit power compared to EESG and have no inertia, although virtual inertia can be implemented with converters. EESGs commonly deliver approximately 20 kV output voltage, which means that for smaller wind farms wind turbine transformers can be omitted. This is not the case in larger wind farms where a transition towards higher collection voltages is expected.

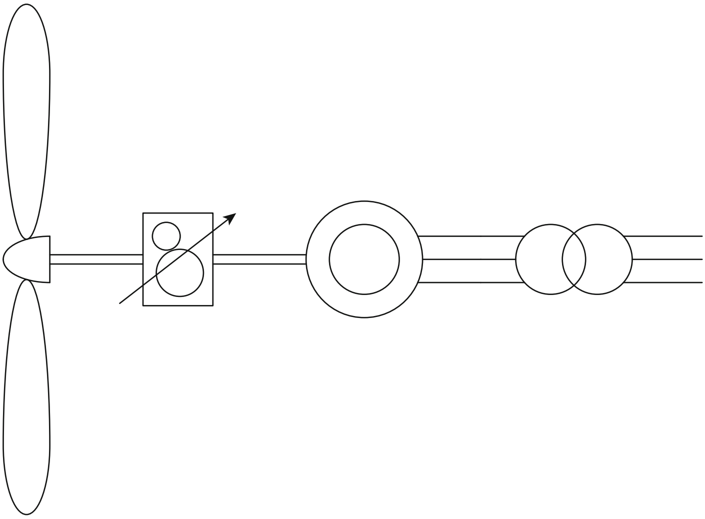

Figure 7.7 Continuous variable transmission drivetrain

Source: Reproduced with permission from Bogi Bech Jensen.

A mechanical continuous variable transmission can be achieved by employing a gearbox with two output shafts (Höhn, 2011). The main output shaft is connected to the EESG and the smaller output shaft is connected to a variable speed drive. The variable speed drive compensates for the variable speed input shaft and ensures that the main output shaft has constant speed, hence, allowing the omission of a power electronic converter.

Continuous variable transmission can also be achieved hydraulically by connecting a hydraulic pump to the wind turbine rotor that then drives a hydraulic motor that is connected to the EESG (Diepeveen, 2013). The continuous variable transmission is achieved by controlling the hydraulic pump/motor system to maintain constant speed at the EESG, independent of the wind turbine rotor speed.

The continuous variable transmission systems have not found widespread use in the wind industry. They have the advantages of omitting the power electronic converter and in some cases omitting the turbine transformer. As there is limited experience with such systems, reliability has not been demonstrated, and their overall performance has not been documented adequately to draw conclusions.

Magnetic pseudo direct-drive generators

A mechanical gearbox can be replaced by a magnetic gearbox (Rasmussen et al., 2005). In a magnetic gearbox there is no contact between the gears and, hence, reliability should be improved. There are bearing friction and eddy current losses in a magnetic gearbox, but no friction between the cogs on the gear. This results in an efficiency that is similar to the mechanical gearbox. The magnetic gearbox can be combined with a generator, which results in a very high torque density solution referred to as the magnetic pseudo direct-drive (PDD) generator (Atallah et al., 2008). The PDD generator has a stator with a magnet array, a rotor with pole pieces, and a high-speed magnet rotor; see Figure 7.8. The PDD generator has a low-speed high-torque shaft but because of the magnetic gear the stator of the generator sees a high-speed field and only has to counteract with a relatively low torque. The combined machine therefore has a torque equal to that of the direct-drive generator, without requiring the large size of a direct-drive generator. The result is a drivetrain with very high torque density. Magnetic PDD generators require a full converter and have the disadvantage of using more rare earth materials than a direct-drive PMSG. However, manufacturers are trying to overcome this by using a combination of electromagnets and permanent magnets.

Superconducting direct-drive generators

Equation 7.5 stated that the torque of a generator is proportional to the electric loading (A), the airgap flux density (Bg), and the volume of the machine

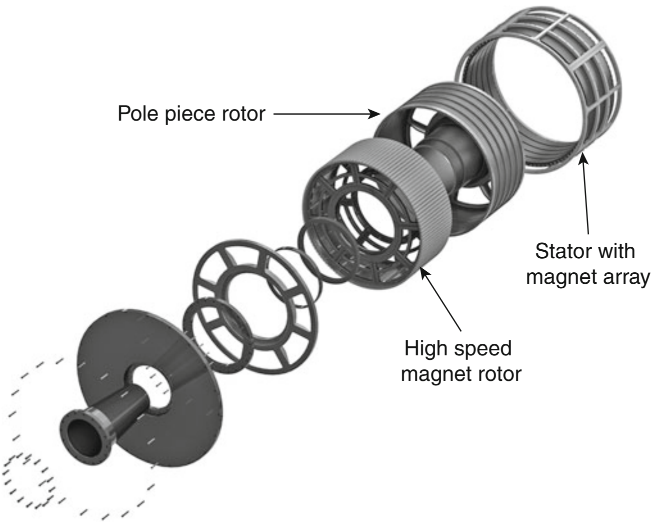

Figure 7.8 Schematic of a magnetic pseudo direct-drive generator
Source: Reproduced with permission from Magnomatics Ltd.

(V). This means that if the airgap flux density is increased by a factor of 2–3, the volume can be decreased by a factor of 2–3 provided that the torque does not change. This is normally not possible because the flux density from the permanent magnets and the electromagnets is limited by the saturation of the iron. This normally results in most large wind turbine generators having a peak airgap flux density of around one Tesla.

In a superconducting synchronous generator, superconductors are employed on the rotor. As superconductors have no losses, the engineering current density can be 100 times higher than with copper. This means that if a certain cross section of copper carries 1 kA, the superconductor can carry 100 kA, which results in a very large force to drive the flux in the machine. Because of this the airgap flux density in a superconducting generator is not limited by the saturation of iron and can reach 2–3 Tesla. This leads to a generator that is only a third in size compared to a conventional generator.

Figure 7.9 gives an illustrative comparison of three different drivetrains. The first is the conventional geared drivetrain (a), where either a permanent magnet or an induction generator is employed. The second is a direct-drive drivetrain with either a permanent magnet or an electrically excited generator. The third is a superconducting direct-drive drivetrain. The figure illustrates that the superconducting generator can become significantly smaller than the conventional direct-drive generator.

Because of the potential size advantage, superconducting generators have become interesting for large offshore wind turbines (Jensen et al., 2013). The

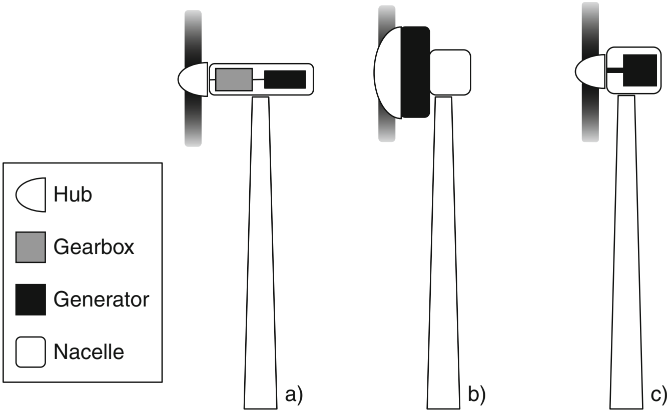

Figure 7.9 Potential size reduction with direct-drive superconducting generators. (a) conventional geared drivetrain, (b) conventional direct-drive drivetrain, (c) superconducting direct-drive drivetrain

Source: Reproduced with permission from Bogi Bech Jensen.

reason for this is that offshore wind turbines are continuously becoming larger in rating, which results in very large and bulky generators, particularly if a direct-drive solution is chosen. The potential size and weight reduction of the superconducting generator means that the entire top head mass of the wind turbine can become lighter, which again results in a cheaper and lighter construction.

Superconducting generators therefore have very attractive features; however, they also have significant challenges. So far no wind turbine has been equipped with a superconducting generator. There is therefore no data on the reliability of such generators in wind turbines. In addition very few superconducting generators have been built; hence, the global data set is quite limited. The reason that very few superconducting generators have been built is because the superconductors are very expensive and also because they have to be cooled down to approximately minus 230°C. The cooling in itself is not a major challenge; however, when the cooling is combined with the required guaranteed reliability of an offshore wind turbine, where every day of downtime is worth thousands of euros, then the cooling system becomes a challenge. The superconductors are expected to come down in price, but are currently very high.

Nonetheless, superconducting technology is so interesting for wind turbines that three different companies, including General Electric and AMSC, have proposed this technology for their wind turbines (Jensen et al., 2013). In addition, the patent development in this field has also ramped up significantly in the last decade. This could be interpreted as the major companies preparing for a potential shift in technology.

Conclusions

The major driver in the wind industry is cost-of-energy (CoE). As this includes everything from reliability, the cost of the wind turbine, cost of installation, cost of operation, energy capture and so on, it is the ultimate performance indicator of any wind farm. CoE is what drives innovation in the wind sector.

Wherever possible, wind turbines are installed onshore, as this leads to lower CoE. However, it has become more difficult to obtain planning permission onshore in Europe, which is why offshore wind farms have become popular.

With focus on CoE, wind turbines have become larger over the years and more energy-efficient and reliable systems have been employed. There is a clear focus on reducing CAPEX by reducing production costs and installation costs. The production costs are being lowered by adopting mass-production techniques from other industries, and the installation costs are being lowered by employing dedicated installation equipment, which is designed for the purpose of easing the installation of offshore wind turbines. An example of this is a Danish installation ship which is only intended for installing offshore wind turbines.

CoE is also forcing manufacturers to research and invest in reliable and fault-tolerant components. Converters and generators are becoming segmented such that a failure in one segment does not result in a breakdown, but only in a partial de-rating. Early fault detection using a wide span of techniques is also being installed in wind turbines. This ensures that developing faults are detected before they become critical. In this way preventive maintenance can be carried out before the wind turbine fails. If an offshore wind turbine breaks down during the winter it can take weeks or even months before the weather allows for maintenance. This would result in substantial lost income and, hence, should be avoided by early fault detection.

CoE is also enticing wind farm developers to increase the collection voltage, so that cables connecting the wind turbines can be reduced in size and losses in the collection grid can be reduced.

There is no convergence towards a single winner for wind turbine drivetrains. On the contrary more drivetrain solutions are being proposed, all of which have their advantages and challenges. The three commercially available variable-speed topologies presented in this chapter are expected to remain in the coming years. Whether one of the presented alternative generators will dominate the market remains to be seen. The continuous variable transmission has the clear advantage of omitting the converter, although other challenges have not become clear yet. The magnetic PDD generator will deliver very high torque densities but has the disadvantage of requiring large amounts of rare earth magnets. The superconducting generator can deliver very high torque densities that should be higher than the PDD, although this has yet to be proven in practice. The superconducting generator requires sophisticated cooling systems and production upscaling of the superconductor.

Wind turbine development is therefore in full swing and it is very difficult to predict what technologies will be employed in a decade. The only thing that is certain is that any technology that does not lower the cost-of-energy will be brutally dismissed. Only technologies that lower the cost-of-energy will prevail.

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8

Early Promoter of Solar Photovoltaics: Forty Years of Development of Policy and Technology in Japan

Kenji Asano

Introduction

Strategies for reducing global warming have led to high expectations for the incredible potential of solar photovoltaics (PV) as a renewable energy technology, and research and development are proceeding in many countries. Japan is one of those countries, and was the world leader in the PV market through and after the late 1990s.

In 2005, however, Japan lost its position as the country with the highest PV installation rate and production level. Germany surpassed Japan's total installed capacity in 2005 and Spain's in 2008. Germany and China both exceeded Japan's production volumes in 2008. Japanese companies like Sharp and Kyocera, which once boasted overwhelming shares of the world market, now lag behind startups like Germany's Q-Cells, China's Suntech, and the United States's First Solar.

This loss of leadership has been blamed on policy failure,[1] and since 2009 has resulted in a series of policies to promote PV diffusion. The goal of a feed-in tariff (FIT), which was implemented in Japan in July 2012, is not only to increase production levels of PVs, thus promoting economic growth through expansion of related industries, but also to provide a path leading to independence from nuclear power, thus improving energy security.

The development and diffusion of advanced technologies are closely tied to the public interest, like those for renewable energy sources, which will be insufficient if left solely to market forces (Pavitt, 2006). Governmental policies related to R&D and diffusion for PV also play an important role (Avril et al., 2012). In the present Japanese context, many make claims that early spread of PV induced by FIT will lead to nuclear independence, and that PVs should be given preferential treatment as a particularly effective method of FIT implementation (e.g., Oshima, 2010, 2011; Ueta and Kajiyama, 2011; Son and DeWit, 2011).

However, it is somewhat difficult to claim that large-scale investment spurred by FIT will offer an internationally competitive edge to Japanese PV firms and thus help invigorate the Japanese economy. Techno-economics holds that the process of technology development and diffusion is rife with uncertainty, making the effect of government policies with such goals even more uncertain. Through the Sunshine Project and other measures, Japan has been using policy to promote PV development and diffusion since the oil crisis, over 30 years ago. Yet, as existing research (see for example Kimura and Suzuki, 2006) points out, while such policies have played an extremely important role in PV R&D and diffusion in Japan, the end results are not always those envisioned by policy-makers – unexpected events influence outcomes in equally unexpected ways.

This chapter examines the formation process of R&D and diffusion policies related to PV in Japan since 1974, as well as the influence that FIT has on PV development and deployment. Particularly important questions are: (a) why Japan was at one time the world leader in PV manufacture and adoption, (b) how it lost its leading position, and (c) whether the FIT in Japan leads to a healthier PV market, and thus long-term economic growth. More specifically, this chapter argues against the conventional wisdom that policy failure was the reason for the downfall of the Japanese PV manufacturers. The reason was not that Japan in 2005 abolished the subsidy for residential PV installations and was reluctant to implement FITs; rather, the reason was that Japanese manufacturers failed to procure supply routes for silicon, delaying their ability to scale up production, and made the wrong technological choices during what were big fluctuations in PV demand and poly silicon supply in late 2000, compared to their Chinese rivals.

How did Japan become the world's largest producer and installer?

Overview of development and diffusion policies in Japan

Japan was the world leader in PV manufacture and installation until 2005. Examining the history of PV development and diffusion up until that year, Kimura and Suzuki (2006) divide the timeline into four phases, based on the presence of support policies and trends in PV manufacture and diffusion.

(1) Phase I (1953–73): PV development for remote, independent power

Starting with its invention at Bell Labs in 1953, PV is looked to as a method of providing an independent power supply for remote places, such as satellites, radio relay stations and automated lighthouses.

(2) Phase II (1974–83): PV development as part of the Sunshine Project

The first oil crisis led to the establishment of the Sunshine Project, of which the development of PV technologies was a central theme. The second oil crisis led to an expansion of the Sunshine Project and dramatically increased budgets for PV development.

(3) Phase III (1984–94): Demonstrating the results of the Sunshine Project, and market formation for consumer-oriented PV applications (electronic calculators, etc.)

This is a period during which Sunshine Project R&D pays off in the form of demonstrable technologies. Amorphous PV becomes practical, creating a market for consumer-oriented PV applications. This is by no means a large market, however, and many firms cease to perform R&D.

(4) Phase IV (1994–2005): Diffusion of home-use PV systems

Residential-use PV systems become practical during this period, greatly promoting their diffusion. This directly leads to the deregulation of PV installation restrictions, the establishment of technologies for system interconnections, power companies' development of excess electricity purchase plans, and the introduction of ancillary businesses.

In summary, Phases I through III were times of post-oil shock R&D, as exemplified by the Sunshine Project, and the 1990s was a period of market creation, during which governmental policies contributed to securing Japan's strong position as a leader in PV manufacture and diffusion. This chapter adds the following Phase V to the above-mentioned Phases I-IV by Kimura and Suzuki (2006).

(5) Phase V (2006–12): 'Policy failure' and implementing a FIT

Japan lost its position as world leader in terms of PV installed capacity in 2005 and in production volumes in 2008 (see Table 8.1 and Figure 8.1). This was widely viewed as being due to policy failures, and since 2009 a number of new policies to promote diffusion have been introduced. September 2009 saw a regime change to the Democratic Party of Japan (DPJ), whose manifesto included extending the FIT to cover all forms of renewable energy. A committee was formed to create a rough outline for an FIT, and following the March 2011 Fukushima nuclear plant disaster, the plan was enacted in July 2012.

Uncertainties in development and diffusion policies

The above certainly indicates that R&D resulting from the 1974 Sunshine Project and market-creation policies established in the early 1990s played a vital role in the development and diffusion of PV in Japan.

At the same time, however, the outcomes were not always those envisioned at the outset; unpredictable events brought about equally unpredictable influences (Kimura and Suzuki, 2006). For example, the Sunshine Project was initially established to investigate solar thermal-power generation, but

Table 8.1 Annual installed capacity of PV by selected countries, 2001–12 (MW)

	Source [*]	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Cumulative [2]**
Germany	[1]	110	110	143	635	906	951	1,274	1,955	3,799	7,411	7,500	7,604	32,411
Italy	[1]	1	2	4	5	7	13	70	338	723	2,321	9,305	3,337	16,250
USA	[1]	29	44	63	101	103	145	207	338	448	918	1,867	3,313	7,221
Japan	[1]	123	184	223	272	290	287	210	225	483	991	1,296	2,000	7,000
China	[1]	6	–	10	10	5	10	20	40	160	500	2,500	3,510	7,000
Spain	[1]	2	3	5	11	25	99	557	2,758	60	392	345	223	5,100
World total	[2]	356	479	585	1,132	1,412	1,582	2,575	6,708	7,376	17,065	30,391	31,095	102,156

Source: [*]; [1] IEA-PVPS (2007, 2011, 2013); [2] EPIA (2013).

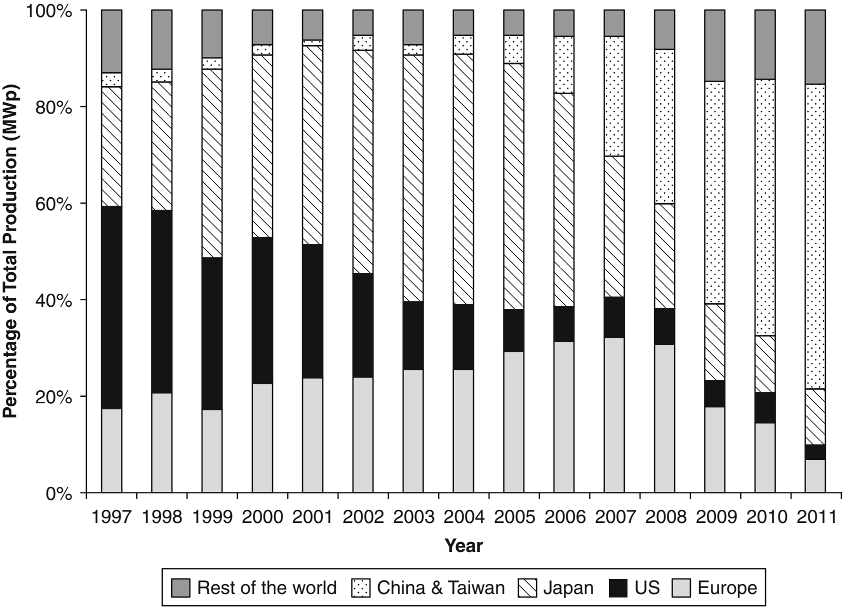

Figure 8.1 PV cells/modules production by region for selected years (percentage of total MWp produced)

Source: Navigant Consulting (2012).

efforts in that direction ceased in 1981 after realization that, contrary to initial predictions, there was little chance of such technologies leading to significant economic development in Japan. Yet this unexpected failure of solar thermal-power generation led to re-budgeting that, in turn, led to significantly increased budgets for PV research in the 1980s and beyond.

As another example, the 1994 Project for Promoting Residential Solar Power Generation Systems, a system for partially reimbursing the cost of installing residential PV systems, did in the end become a factor for promoting the diffusion of residential PV systems, but the project was considered a gamble since the consumer response was impossible to predict. At the time, the cost of installing a PV system was quite high compared to electricity rates, even when installation subsidies were considered. While the cost of a PV system fell from ¥2,000/Wp in 1994 to ¥730/Wp in 2002, this still meant power-generation costs of ¥70/kWh even after subsidies, which was far more expensive than the ¥22/kWh, which is the average electricity price paid by regular residential consumers. Figure 8.2 shows average residential roof-mounted PV system prices (less than 10 kW) in Japan and Germany since 2006. Although the Japanese prices declined gradually from ¥657/Wp in 2006 to ¥427/Wp in 2012, German PV prices dropped to €1.7/Wp in the first

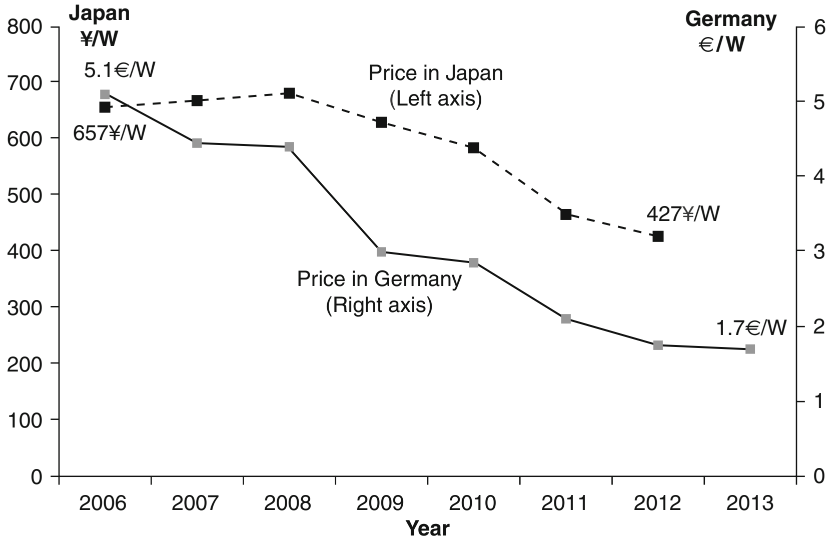

Figure 8.2 Average PV system prices for residential roof-mounted (less than 10 kW) in Japan and Germany from 2006 to 2013

Source: German data from BSW (2013). Japanese data from RTS (2012) and METI (2013).

quarter of 2013, or in other words only slightly above half of the Japanese price.

There was a strongly positive consumer reaction nonetheless, which according to surveys was the result of a desire to support the environment, not to save money (Iuchi et al., 1996). This indicates the existence of consumers who place a high added value on PV systems beyond their capability to generate electricity, and the successful creation of a market for such consumers. The existence of this market led to rapidly decreased costs.

Japanese policies related to PV development and diffusion are, of course, not strictly the result of happenstance and good luck, but one cannot ignore the fact that policies do not always function as intended, and can fail at times. The environment in which the policy target exists can also worsen, so constant evaluation and modification are required. Diffusion policies and subsidies up to the present have been justified as provisional measures required in order to attain independent market growth, but even now, 20 years after such policies were first put into place, cost reductions remain insufficient and markets have not become independent. The Japanese government has set lofty goals for significant economic recovery by 2030, but there will always remain the possibility that desired improvements never materialize, despite the best efforts of policymakers.

How did Japan lose its leading position?

Was it due to policy failures?

In 2005 Japan lost its position as world leader in terms of PV installations, and in annual production volumes in 2008. This was widely viewed as being due to policy failures, and since 2009 a number of new policies to promote diffusion have been introduced. The expiration of residential PV system installation subsidies in 2005 is considered a prime example of such failure, and is seen as the primary reason why 2005 was the year that Germany took Japan's top position for PV system diffusion.

The main reason for the abolishment of these subsidies was the 2003 Ministry of Finance fiscal budget audit, which evaluated the impact of PV installation subsidies and the need for continued support ten years after implementation of the system. The audit found that (a) the subsidy rate (the ratio of subsidy amounts to system costs) was decreasing each year, resulting in lowered incentives for PV installation; (b) there were increased subsidies offered by local governments; and (c) system costs had fallen to the initial goal of ¥400,000/kW, meaning that the goal of the subsidies – establishment of a solar power market – had been more or less fulfilled. Subsidies for 2004 were therefore capped at half their previous level (that is, capped at ¥5.25 billion in total, or ¥40,000/kW). The subsidies were eliminated in 2005.

The result was that Japan fell to third place in terms of PV system installations, being surpassed by Germany in 2005 and Spain in 2008. The subsequent reduction in production quantities had the consequence that a number of Japanese manufacturers were faced with plummeting sales. Japanese companies had long led the world in PV technical development, but in 2006 they began to rapidly lose market share (see Figure 8.1), and these days Japanese firms account for only 6 percent of the market for PV cells, while as of 2012 Chinese firms control 62 percent of the market (*PV News*, 2013).

In June 2008, Prime Minister Fukuda put forth the 'Fukuda vision' of regaining the number-one spot, which called for increasing PV installations to ten times the current levels (14 GW) by 2020, and 40 times the current levels (53 GW) by 2040. As part of this initiative, the cabinet established the 'Action Plan for Achieving a Low-carbon Society', with the goal of creating demand for innovation by striving to reduce by half the cost of solar power systems within three to five years. The plan also called for consideration of the renewable energy policies of Germany and other countries, and consideration of bold new subsidies and energy rates.

Subsidies for residential PV system installations resumed in January 2009 under Prime Minister Aso, who had taken over for Fukuda in September 2008. A PV–FIT policy took effect in September 2009, allowing excess electricity generated from PV systems smaller than 500 kW to be sold. Toshihiro

Nikai, then minister of Economy, Trade, and Industry, declared that the next three to five years would be crucial to the price competitiveness of solar-power generation, and that it would be necessary for power companies to approximately double purchase prices over the following decade. This PV–FIT policy set the electricity purchase price at ¥48/kWh for the period September 2009 through March 2011, and ¥42/kWh thereafter, for a minimum of 10 years.

Unsatisfied with just regaining the number-one position for solar-power installations, the Aso cabinet added manufacturing levels as well. As part of the policies announced in April 2008 to address the global economic crisis, a plan for leading the world in solar-power generation was positioned as the most important project in a planned 'low-carbon revolution'. Specifically, goals for solar-power installations were set at 20 times current values by 2020 (28 GW, double the Fukuda administration goals), and a PV–FIT would be used to stimulate demand and thus increase production.

Voluntary buyback plans from the power companies preceding introduction of the PV–FIT were for a purchase price of around ¥24/kWh, so the FIT-established price represented an approximate doubling (Table 8.2). Given that European FIT systems such as those in Germany and Italy established PV buyback prices of €0.20/kWh or less (translating to roughly ¥26/kWh), this represented a relatively favorable FIT price structure for PV systems.

Standardization of PV manufacturing technology

The common claim that Japan's loss of its top position in PV manufacturing was the result of policy failures is difficult to support. The primary cause

Table 8.2 Purchase price of PV in Japan's renewable policy, 2009–13

Purchase scheme	**RPS/ voluntary agreement**	**PV-FIT**		**FIT**		
Purchase price (¥/kWh)	**Until Aug. 2009**	**Sept. 2009–March 2011**	**April 2011–June 2012**	**July 2012–March 2013**	**March 2013–April 2014**	**Purchase period (years)**
Residential (<10 kW)	24	48	42	42	38	10
Non-residential (more than 10 kW, less than 500 kW)		24	40	42	37.8	20
Non-residential (more than 500 kW)		24	24			20

of the change was rather the generalization and standardization of crystalline silicon manufacturing technologies that took place in the mid-2000s. These technologies spread to Chinese and Taiwanese startups, which rapidly expanded production volumes to realize cost savings (Meersohn and Hansen, 2011; Grau et al., 2012). Japanese PV manufacturing firms, in contrast, failed to procure supply routes for silicon, delaying their ability to scale up production (Marukawa, 2012).

According to Marukawa (2012) standardization of PV manufacturing technologies has since led to the rapid market dominance of Chinese startups. Almost all current residential PV systems are of the monocrystalline or polycrystalline silicon type. While First Solar's CdTe-type products are competitive with crystalline silicon at utility company scales, crystalline silicon dominates the overall market. Silicon-type PV manufacturing is now a turnkey technology, so factories to produce cells and modules can be quickly set up. Semiconductor chips require silicon substrates subject to similar processing, but the required silicon purity in the current generation of crystalline silicon-type cells is far lower, and far fewer manufacturing steps are required. There are even fewer manufacturing steps and intermediary members than are needed for liquid-crystal panel manufacture. Improvements in energy conversion efficiency for crystalline silicon PV are approaching theoretical limits, meaning that future competition will be based on unit price per watt, not improved performance.

Table 8.3 summarizes the key characteristics of the different PV technologies, focusing especially on costs, conversion efficiency and market share.

Crystalline silicon (c-Si) modules represent 89 percent of the global module production in 2012, compared to 86 percent in 2011 (*PV News*, 2013), with their low costs and the best commercially available efficiency. C-Si modules can be categorized as single crystalline (sc-Si) or multi-crystalline (mc-Si). Although very significant cost reductions occurred in recent years, the costs of the basic materials are relatively high, and it is not clear whether further cost reductions will be sufficient to achieve full economic competitiveness in the wholesale power-generation market (IRENA, 2012).

In contrast, thin film has decreased the module share from 21 percent in 2009 to 11 percent in 2012, which reflects the steep cost reductions and efficiency improvements experienced by c-Si in 2011 and 2012 (*PV News*, 2013). Thin film is categorized in the following three types: (a) amorphous (a-Si) and micromorph silicon (a-Si/μc-Si), (b) Cadmium-Telluride (CdTe), and (c) Copper-Indium-Diselenide (CIS) and Copper-Indium-Gallium-Diselenide (CIGS). Although thin-film technologies have relatively low material and manufacturing costs, they face issues of cost competitiveness against very low c-Si module prices.

Marukawa (2012) classifies the following four technology-determined strategies of global PV manufacturers. The first strategy focuses on efficiency improvement, for which sc-Si has the most efficient performance.

Table 8.3 An overview and comparison of major commercialized PV technologies

		Crystalline silicon (c-Si)		Thin films			
Technology	**Units**	**Single crystalline silicon (sc-Si)**	**Polycrystalline silicon (pc-Si)**	**Amorphous silicon (a-Si)**	**Copper Indium Gallium Diselenide (CIS/CIGS)**	**Cadmium Telluride solar cells (CdTe)**	**Source**
Commercial PV Module efficiency at AM1.5*	%	15–19	13–15	5–8	7–11	8–11	[1]
Confirmed maximum PV Module efficiency	%	23	16	7.1–10	12.1	11.2	[1]
Current PV module cost $/W	$/W	<1.4	<1.4	<0.8	<0.9	<0.9	[1]
Market share in 2012	% (Production, GW)	89% (31.4 GW)		4% (1.4 GW)	2% (0.8 GW)	5% (1.9 GW)	[2]

*Note: Standard Testing Conditions, temperature 25°C, light intensity 1000W/m^2, air mass 1.5.

Source: [1] IRENA (2012); [2] *PV News* (2013) No. 5.

A so-called HIT (heterojunction with intrinsic thin layer) cell, developed by the Japanese company SANYO, combines sc-Si semiconductors with a-Si layers. However, due to high production costs, the cell will be an optimal choice only for small-scale residential PV plants, and thus the size of the market remains small.

The second strategy is to adopt easily accessible technologies, like mc-Si, and decrease production costs through low input costs and large-scale production (Marukawa, 2012). This strategy has been pursued by Chinese manufacturers. As previously explained, they rapidly expanded production volumes so as to realize steep cost reductions.

The third strategy is to select thin film, which has the potential for efficiency improvement. This strategy was pursued by Sharp in Japan (Marukawa, 2012). With the steep increase of the polysilicon price during 2006–8, the strategy was thought of as effective since the manufacturer could economize the consumption of silicon with efficiency improvement.

The fourth strategy is to protect intellectual property rights and vertical integration of CdTe fabrication. This has been done by U.S. manufacturer First Solar (Marukawa, 2012). First Solar's CdTe-type products are competitive with c-Si at utility scales. However, the global market share of thin film, including CdTe, will be expected to decline further, with a number of market exits expected from residential and mid-size PV systems over the course of 2013 (*PV News*, 2013).

Expansion of European markets and Japan's delayed response

A secondary reason for Japanese PV-related firms being no longer market leaders is attributable to delays in scaling up due to failures to secure procurement methods for silicon, the main raw material required (Marukawa, 2012). The FIT policies of Germany, in 2004, and of Spain, in 2007, made PV an attractive investment product, leading to rapid expansion of demand. PV industry startups (such as Chinese manufacturers) used stock offerings and other methods to raise the funds required to rapidly ramp up production, rising with blinding speed to the top ranks of worldwide manufacturing shares. In contrast, Japanese PV firms misread the speed at which the market would expand. The supply of silicon at the time was tight,[2] which delayed the ability of Japanese firms to find raw materials, resulting in lost market share. The threat of an inability to secure silicon led many Japanese firms toward planning for large-scale manufacture of thin-film silicon PVs, which have poor conversion efficiencies but very low manufacturing costs. However the price of polysilicon had dropped sharply from $450 per kilogram in April 2008 to $65 in May 2009, since Spain capped annual PV installation, and several solar-grade polysilicon manufactures began operation. Thus, at the time of writing the market for thin-film PV has not lived up to initial expectations.

The above describes how standardization of PV manufacturing technologies and failure to scale up production volumes led to a delayed response from Japanese firms, and became the main factor in Japan's loss of its previous top position. Nonetheless, policy failures such as the abolishment of the residential PV installation subsidies in 2005 have been pointed to as the cause. The result has been the continuous expansion of PV–FIT and FIT policies since 2009.

Will the Japanese FIT lead to large learning effects and to the stimulation of related industries of PV?

Japan shifted from RPS to FIT following the Great East Japan Earthquake

Expectations for renewables (RE) to replace nuclear as a power source have been growing in Japan following the accident at the Fukushima Daiichi Nuclear Power Plant precipitated by the Great East Japan Earthquake on March 11, 2011. The central policy mechanism for this is the FIT mechanism, passed by the Diet in late August 2011, around six months after the earthquake, and introduced on July 1, 2012. In the FIT system, the government requires power companies to purchase power from renewable energy sources at a 'fixed' rate over long-term periods of around 20 years. This system therefore makes renewable-energy power companies low-risk investments by securing a long-term fixed electricity retail price, and this has led to their popularization and expansion.

Since April 2003, the renewable portfolio standard (RPS) mechanism has been implemented in Japan. Similar to FIT, RPS ensures that output from RE is purchased at a price exceeding that of normal wholesale electricity.

Although the FIT and RPS mechanisms are the same in that they both incentivize increased RE output and are being adopted in countries around the world,[3] they differ in that government regulation under FIT targets the purchase price, while under RPS it targets installed capacity. That is, if FIT is subject to price regulations, RPS is subject to quantitative regulations (Lauber, 2004; Menanteau et al., 2003).

Many previous studies that have compared the two mechanisms claim that with respect to wind power FIT is superior in terms of cost-effectiveness. For example, in a comparison between Germany's FIT mechanism and Britain's RPS mechanism in terms of wind power, Butler and Neuhoff (2008) conclude that Germany has adopted an overwhelmingly greater capacity and is better even when comparing total purchases by output with uniform installation conditions such as wind conditions. Therefore, before Japan decided to shift from RPS to FIT, an evaluation was conducted of countries that had implemented it early on. Under Japan's RPS, RE accounted for no more than 10 percent of the power-supply ratio, so aiming to curtail the country's dependence on nuclear power in the mid-term, the political decision was made to change from RPS to FIT owing to its proven expansionary effects in countries such as Germany.

However, FIT has met with mounting criticism due to its increased cost burden, most notably with regard to the adoption of photovoltaic power (PV). For example, the accumulated adoption of PV in Germany at the end of 2012 was 32 GW, some 30 percent of the global total. In addition, the costs required for the FIT are added to electricity rates as a surcharge. In Germany, the 2013 surcharge has increased by 47 percent year-on-year to €0.053/kWh, bringing the total annual amount to over €16.5 billion. Even though the German government has announced various measures to control the surcharge, it is expected to rise further in 2014, so a more cost-effective policy leveraging market principles has been recommended (see Frondel et al., 2011; German Council of Economic Experts, 2012; IEA, 2013) and is currently being explored. In short, Germany – on which Japan models itself – is now dealing with the 'over-adoption' and 'increasing cost burden' of RE, and is hard-pressed to bring down the purchase price.

Therefore, given the early experiences with FIT in countries like Germany, Japan needs to pay attention to whether implementing FIT is working for policy purposes. The goals are that: (a) through so-called learning effects the FIT will create a large-scale demand for renewable energy, and will simultaneously cause a decrease in the unit price of products and, (b) lead to the stimulation of related industries and job creation through increased demand. In the following, this chapter asserts that under the current conditions, Japan's FIT will end in a result of 'chasing after two hares and catching neither'.

Small contribution of learning effects for Japan's FIT

Regarding the primary goal of the FIT 'to reduce costs by creating a market via policy', prices did indeed fall dramatically when Chinese manufacturers flooded the global market by increasing production, with the expectation of an expanded market due to the FIT in Europe. However, at the current point in time when crystalline silicon production techniques are widely available, economies of scale cannot be expected.

The global cumulative capacity has increased from 13,430 MW in 2008 to over five times that amount at 67,350 MW in 2011, with 80 percent of that capacity in Europe. Over the same period, cumulative production rose from roughly 19,000 MW to more than 92,000 MW, with a surplus capacity supply (a stockpile) in excess of 25,000 MW (EPIA, 2012).

Manufacturers in China and Taiwan were responsible for this sudden increase in production over this period. The share of annual global production held by these two countries rose from approximately 30 percent in 2008 to 64 percent in 2011 (see Figure 8.1). Chinese manufacturers in particular account for three of the top five PV module producers in 2012 (*PV News*, 2013).

The unit price of PV products fell rapidly due to the massive stockpile that resulted from this increase in production. According to the magazine Photon, in Germany the price of modules fell by roughly two-thirds over the three years since 2009. The spot price of modules has fallen from €2.7/W in January 2009 to €0.8/W in December 2012. As the system price is roughly double that of the module price, Germany's PV system price has fallen from around €4,500/kW in 2008 to €1700/kW at the end of 2012, or roughly a third over five years (see also Figure 8.2 above). The corresponding prices in Japan as of 2012 are at a level of ¥427,000 (€3280)/kW,[4] or more than double the German price.

While it is possible that prices may continue to decrease temporarily in the future due to the large stockpile, the margin for reduction of fixed costs through economy of scale is limited. This is because the techniques for manufacturing crystalline silicon PV products, which have become the current standard, are widely available. The majority of the cost is the variable cost of materials, and the margin for improving conversion efficiency is also limited. Consequently, even if Japan were to create a market via policy through the FIT, it is unlikely that international prices of PV products would decrease.

Will FIT in Japan promote the development of domestic PV manufacturers?

Next, what about the FIT's second objective of promoting PV related industry? As many researchers have pointed out, manufacturers of PV cells and modules in industrially advanced countries earn almost no profits. For example, the share of global production held by Japanese PV manufacturers exceeded 50 percent in 2005, but in 2012 it had fallen to 6 percent, and the volume of exports had fallen as well. In Figure 8.3 the bar graph shows the proportion of domestic and export sales volume of Japanese manufacturers, while the line graph shows the value of export sales. In 2008, 80 percent of the production was exported, with a value of approximately ¥340 billion.

However, with the sudden drop in the unit price of products caused by the previously mentioned entry into the market by Chinese manufacturers and their increase in production, the international competitiveness of Japanese manufacturers has declined significantly. As exporting became difficult, the proportion of domestic-to-export sales became almost equal in 2011, and the value of exports fell to approximately ¥190 billion. This is not limited to Japan, but is common across all industrially advanced countries. Germany's Q Cells SE, which once boasted the highest production in the world, lost in the price competition with Chinese manufacturers and went bankrupt in April 2012.

As described above, the large-scale installation of PV in industrially advanced countries due to FIT did indeed reduce the unit price of PV products, but conversely also meant a decline in export profits and demonstrated

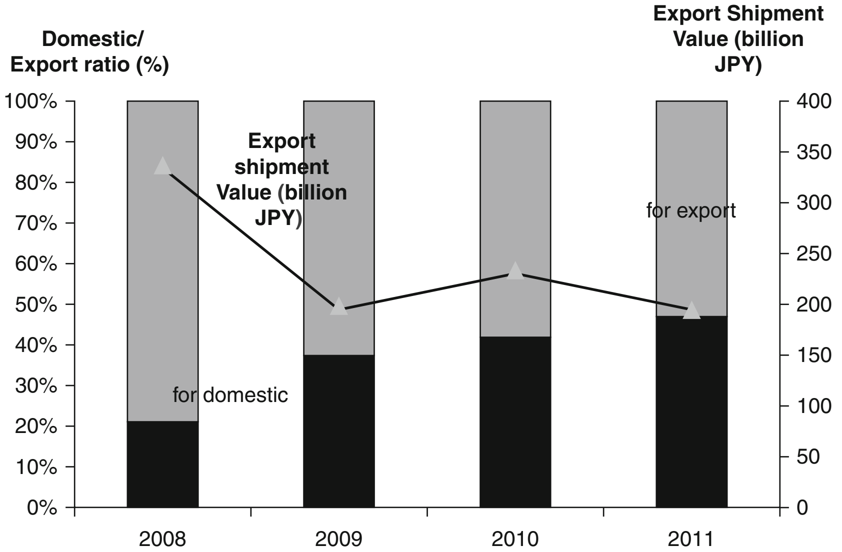

Figure 8.3 Actual value of exports by Japanese PV manufacturers and the proportion of domestic and export sales

Source: Export value figures are from the Japan Tariff Association foreign trade statistics, PV sales figures are from the Japan Photovoltaic Energy Association (JPEA). In other upstream fields, Japanese companies had been strong in surface protection materials and back sheets, but more and more local companies are entering the market in China. This should be interpreted as rapidly declining international competitiveness.

that it was not possible to 'catch two hares' and stimulate domestic industries. If Japan sets the purchase price to ¥42 under these circumstances, it will result either in the stockpile of the global market flooding into Japan, or in a continued massive introduction of the cheapest crystalline silicon components in the current market, which will not contribute to technological progress or stimulate Japanese industries.

Therefore, one of the biggest issues is that the purchase price of PV in FIT is too high, as the price of PV is certain to fall significantly in the future, so there is no reason to greatly discount it. While the price of PV in Japan is definitely high at the moment, the price is falling as its import share increases. According to Nomura (2013), (a) while a cross-country comparison of PV module prices shows that prices in Japan were 2.5 times higher than the average price across 14 major countries as of 2011, (b) import/export data from 2010 to Q3 2012 showed that Japan's import share has grown significantly from 8 to 32 percent, and prices are expected to fall dramatically as domestic production continues to be replaced by foreign units.

As the price of PV modules sharply declines and they become increasingly commodified due to a global supply glut, the cost of generating PV power will follow a nearly identical trend under the same solar conditions. In actuality, the PV purchase price in other countries that adopted FIT early on, when it was still at ¥10–20/kWh, was less than half of what it was in Japan.

Germany has aimed to control the cost burden by cutting the purchase price by around 60 percent in the last four years, but even so has not prevented a rush to adopt PV (IEA, 2013). There is no rational reason for Japan to set such a high purchase price. Japan urgently needs to consider setting a purchase price that remedies the disparity between domestic and foreign prices.

Conclusions

This chapter has examined the formation process of R&D and diffusion policies related to PV in Japan since 2000. Following are my conclusions:

(1) Japan was the world's largest in PV manufacture and installation until 2005. R&D such as the 1974 Sunshine Project and market creation policies established in the early 1990s played a vital role in the development and diffusion of PV. At the same time, however, the outcomes were not always those envisioned at the outset; unpredictable events offered equally unpredictable influences.

(2) Standardization of PV manufacturing technologies and failure to scale up production volumes led to a delayed response from Japanese firms, and are the main factors in Japan's loss of its previous top position. Thus, the common claim that Japan's loss of its top position in PV manufacturing was the result of policy failures is difficult to support.

(3) With the launch of the FIT, together with RPS and PV-FIT, three renewable electricity support policies have temporarily coexisted in Japan since 2012. At a glance, the FIT gives the illusion of balancing the environment with the economy. This is because it appears that it will stimulate current investment in renewable energy, temporarily increase the profits of related companies and create jobs. Maintaining the present high purchase prices in FIT systems will no doubt result in short-term expansion of the domestic market, aiding Japanese PV-related firms and boosting employment.

(4) In the long term, however, this will likely encourage the diffusion of standardized technologies, increasing the inflow of low-cost goods from abroad, and even further lowering the international competitiveness of Japanese PV firms. One must not forget that the true nature of the FIT is to extend the purchase period over 15–20 years, and that this will simply delay the financial burden until a later date. An excessively high purchase price must be avoided at all costs. Deployment of PV and economic growth are not synonymous.

Future PV development and diffusion policies must therefore be enacted under the assumption that they may not work as first intended, and it is vital that such policies are constantly evaluated for effectiveness and technical development strategy as a way to deal with these inherent uncertainties.

Notes

1. It is often claimed that the critical years were 2005 and 2007: The Japanese government abolished subsidies of residential PV installation in 2005, while FITs created a surge in demand for PV in Spain in 2007. Yukinori Kuwano, the former CEO of SANYO, pointed out that Japan lost its leading position because of two policy failures: (a) the abolishment of residential PV installation subsidies in 2005 and (b) too late implementation of an FIT (*Asahi Shimbun*, 2013).
2. During 2006–8, the price of polysilicon increased from $66 per kilogram in 2005 to $300 in October 2006, and to $450 in April 2008.
3. According to REN21 (2012), FIT was implemented in 90 countries and regions by the end of 2012, having been first introduced in the United States in 1978 and Denmark in 1979. RPS, meanwhile, which originated with a 1995 proposal by the American Wind Energy Association, influenced by U.S. emission permits trading, has been implemented in 58 countries and regions, including the United States.
4. Exchange rate set at 1€=¥130.

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9

Smart, but is It Sustainable? The Importance of Reconciling Non-Technical Concerns in Grid-Development Policies

Audun Ruud

Introduction

Electricity grids in Europe are currently undergoing numerous changes. New grid development projects are proposed everywhere. This is partly caused by the Renewable Energy Sources (RES) directive of 2009 that specifies national targets that all countries must achieve by 2020. In Norway the on-shore renewable share is already high – around 60 percent, but as an EEA (European Economic Area) country Norway has agreed to increase this share to 67.5 percent. In Sweden the target is 49 percent, but the government has published the ambition to reach a renewable target beyond 50 percent by 2020. As a consequence, a number of efforts are being made to stimulate renewables. From 2012, a joint certificate market has been established between Norway and Sweden and, for 2020, a target has been set of 26.4 TWh of renewable electricity production. The political commitment to be submitted in accordance with the RES Directive targets will be shared equally between Norway and Sweden, with 13.2 TWh each, but given the market orientation of the policy scheme the actual investment will be located where investors find it most attractive. There are a lot of opinions and much public discussion surrounding renewables (Toke, 2005; Wüstenhagen et al., 2007), but without well-functioning electricity grids, electricity will never reach the market. In the last few years, investments in the upgrade and development of transmission lines have notably increased. Between 2001 and 2008, investments in the Swedish transmission network did not exceed 1000 million Swedish Kronor (SEK). However, by 2013, they are expected to rise to beyond SEK4000 million (Svenska Kraftnät, 2012a). In Norway similar changes and increased ambitions have been published by Statnett, the state-owned enterprise whose purpose is to own, run and develop the central grid.[1]

Why smart grids?

The need for a serious rethink on electricity transmission and distribution is hardly in doubt. In the United States alone the cost of blackouts is estimated at roughly $150 billion. In many countries, the network is rapidly aging. Britain's last major electricity network investments were in the early 1970s, and were estimated to have a lifespan of about 40 years. The need is also pressing for two more reasons. First, electricity consumption keeps increasing. Even taking energy-efficiency improvements into account, the Electric Power Research Institute estimates that for 2008–35 consumption will increase by an annual 0.7 percent. Second, intermittency problem are increasing because of the phasing-in of low-carbon sources of energy like solar and wind power, as these have far bigger power fluctuations than do coal and gas plants. Even today, Germany, with one of Europe's most stable grids, has difficulty maintaining grid stability with renewables supplying 22 percent of electricity demand. But if national targets are to be taken seriously, this will increase to 35 percent by 2020 and 80 percent by 2050. There is no realism to this without serious changes to grid regulation and a technologically more sophisticated grid network (*Economist*, 2013; Knapp and Samani, 2013).

This sophistication takes the form of the smart grid. It is a system that uses modern computer technologies to vastly improve the efficiency. The grid has a set of key technical components. First, reliability is improved through the automation of operations within substations. Second, the phasor measurement unit measures parameters like voltage and current at different grid locations and is synchronized by GPS. This, for instance, allows the operator almost instantaneously to shift the electric load between plants in case one plant is struggling to meet demand and others run surpluses. The phasing-in of renewables requires a system that can satisfy peak demand and major fluctuations, and a system that allows the integration of a multitude of decentralized energy providers, like solar cells. Third, what probably most people think of when smart grids are mentioned is the advanced metering infrastructure, installed directly in the customer's house. It allows consumers to run electric appliances at off-peak hours (during the night), smoothing out peaks and troughs in the energy supply and incentivizing consumers to use electricity at times of the day when the tariff is at its lowest, rather than at times when demand peaks. In wealthy countries we are now seeing the diffusion of smart meters in households, enabling better communication and dialogue between the grid companies, utilities and the electricity customers. This can almost be likened to a kind of electronic surveillance of consumption patterns, enabling better planning of the needs for further grid development (*Economist*, 2013; Knapp and Samani, 2013).

The question is however whether such a technical approach is sufficient to develop the electricity grid that is required in order to realize prevailing energy- and climate-policy objectives. Huge grid investments have been proposed, but there have been frequent cases of opposition against the building of new transmission lines. This has often led to delays or even to the withdrawal of projects (Cotton and Devine-Wright, 2011). One example is the so-called 'Monster-grid' project in the scenic Hardangerfjord area in Norway.[2] The concession application was filed in June 2006, and in May 2008 the Norwegian Water Resources and Energy Directorate (NVE) decided that Statnett should be given the concession for the proposed grid. This concession was subject to a high degree of regional and national opposition, and was appealed to the government. Between May 2008 and July 2010 the Ministry of Petroleum and Energy conducted several new investigations, public hearings and reports. In July the ministry upheld the license for the building the Sima-Samnanger grid. During the late summer of 2010 the ministry appointed four different expert committees that were to scrutinize the possibilities for using underground cables. In March 2011, the ministry upheld the original decision. By then, the Sima-Samnanger grid had produced protests, disputes and conflicts and, in 2010, this particular grid project was the fourth most-discussed issue in the Norwegian media (Ruud et al., 2011). As a direct consequence of these disputes, the government proposed revisions to national grid-development policies, proposals that were unanimously approved by the Norwegian Parliament in 2012.

The challenges addressed in the dispute related to the Sima-Samnanger grid project were to a large extent oriented towards underwater sea connectors. This was also a major reference point for the four expert committees. There are still major technological and economic challenges related to grid development, but in a review of the major R&D projects looking at the promotion of renewables in Europe, Lafferty and Ruud (2008) documented that the orientation of the projects had a strong bias towards either improving technological performance or improving market penetration and learning. With very few exceptions, other types of variables like geography, history, institutions, culture or more normative approaches were treated as 'residual' factors. Currently, there are strong arguments for developing smart grids. This is a central theme in the Strategic Energy Technology (SET) plan that the EU commission has formulated as the technology pillar of EU energy and climate policy. A core reference point for current efforts of developing the electricity grid in a smarter direction is the European Electricity Grid Initiative (EEGI) in which core transmission- and distribution-grid companies are actively involved. Although notions like public acceptance may be given a mention, the approach often remains quite technical or market oriented. There are core technical and market-related challenges for developing the electricity grid in a more sustainable direction. However, the main argument discussed in this chapter is that such a technical approach may easily become insufficient. Efforts at developing the electricity grid like the EEGI may appear smart both technically and economically, but will it be sustainable unless other non-technical concerns like public acceptance and human behavior are addressed in conjunction with the techno-economic policy concerns?

In this chapter – drawing on findings from the SusGrid project[3] – I will argue that it is crucial to consider the barriers and opportunities posed by the development of electricity grids per se, for the achievement of greener and more sustainable energy systems in line with energy- and climate-policy objectives, both in the EU, and worldwide. In line with the analytical orientation of the SusGrid project, I argue that it is important to examine the development of electricity networks as socio-technical systems and, through that, discuss the possibilities for promoting more *sustainable grid development regimes* (GDR) which encompass global and local environmental dimensions of the transport of energy from renewable sources, as well as economic and social dimensions in a balanced and integrated way. For that task, in the next section I will discuss the relevance of conceptualizing electricity networks and their components as socio-technical systems and, within that perspective, the meaning and dimensions of a sustainable electricity grid regime. Then, to illustrate our proposal on how to investigate and foster the sustainability of grid development regimes, I will examine the national Norwegian regime in more detail, bringing in comparative data from Sweden in order to better examine and assess this regime. By expanding traditional approaches, current efforts at promoting smarter electricity grids may even become more sustainable!

Based on the perspective of sub-optimization in line with the reasoning of Simon (1957), I suggest that optimizing the outcome for merely a subsystem in a grid development regime – like the introduction of smart metering – will in general not optimize the outcome for the system as a whole. The aims of promoting smart grids is to strengthen two-way communication and improve involvement among customers, but the question is whether the citizens experiencing the actual development of electricity grids really experience the current efforts as smart. With explicit reference to current grid policy practices and licensing procedures in Norway and Sweden, this chapter questions whether the technical smartness is necessarily politically smart. Changes in the prevailing grid development regime are needed. Smart grid developments are very promising, but there is a need for more systematic treatment of non-technical concerns as well. There is for instance a clear need for more communication and dialogue with respect both to the development of the central grid and to households. Customers as citizens can more jointly be involved in the development of a more sustainable grid regime, which is crucial to realize energy- and climate-policy objectives.

An extended analytical approach to sustainable grid development: What is triggering change?

Lafferty and Ruud (2008) argue that numerous barriers to increased renewable shares in the energy system do not lie in techno-market factors themselves, but in variables that condition techno-market effects. Based on this observation, an extended approach was developed in which more contextually specific instruments and references were incorporated. This approach distinguishes between two types of conditioning variables with respect to the dominant promotion model: (a) Structural variables conditioning energy-system resistance to RES – which can also be referred to as path dependence; and (2) contextual variables conditioning the actual introduction and integration of renewables in specific regional–local settings, what we refer to as path creation.

By 'structural variable' we mean a conditioning influence that is traceable to patterns of interdependent material, social, cultural, ideational and normative factors that have become relatively 'fixed', and relatively resistant to change, within the collective activity of the community in question. We argue that not only the technological and economic aspects are of importance, but also the social, political, regulatory and cultural aspects. It is the interdependence between these that shapes the configurations for improved governing strategies for promoting renewables.

A core European initiative promoting smart grid: the EEGI

To illustrate the need for an extended approach, let me refer to the European Electricity Grid Initiative (EEGI) created by network operators of both transmission – represented by ENTSO-E[4] – and distribution grids – represented by EDSO – to accelerate the development of Europe's future electricity networks. The EEGI proposes a nine-year European research, development and demonstration programme. EDSO has explicitly related its strategic orientation to smart grid.[5]

According to the EEGI the promotion of a smart grid requires efforts that:[6]

(1) actively integrate efficient new generation and consumption models;
(2) coordinate planning and operation of the whole electricity network;
(3) study and propose new market rules to maximize European welfare.

According to the EEGI, traditional solutions could be applied to resolve many of the issues posed by the new challenges. An example of a traditional approach would be to build new lines and substations to integrate more renewable generation. However, the smart grids approach would involve the development of more information and communication technology (ICT) solutions in the network to allow a higher penetration of renewables connected to existing lines and substations. In this case the traditional approach would yield a solution, but one that would be much more expensive, and possibly not feasible because of resistance against new infrastructure or time constraints. This does not mean – according to the EEGI – that more traditional infrastructure is not needed even with the smart grids approach, but it means that the smart grids approach is looking for the most efficient way to meet the new challenges and will be less expensive in the long run. However, the smart grids approach faces several barriers:

- *Technology barriers,*
- *RD&D organization barriers,*
- *market failures and distortions,*
- *incentives and*
- *public barriers* related to customer engagement and public acceptance of infrastructure developments.

The EEGI program has been designed to overcome these barriers: it leans on the Third Energy package adopted by the European Parliament and the Council in July 2009 which, together with other legislation, provides Europe with more appropriate regulatory frameworks for adapting networks to a lower carbon footprint.

A relevant Norwegian initiative

On August 23, 2010 the Norwegian Smart Grid Centre was founded. The objective is to establish a national research, teaching, testing and demonstration centre for smart grid with top international standards. The centre will provide new knowledge and business opportunities, strengthening the international competitiveness.[7]

The core focus of the Norwegian Smart Grid Centre is on demonstration projects, and a number of very promising initiatives have been taken – for instance at Steinkjer and Hvaler. In Demo Steinkjer, energy companies, suppliers, researchers, customers and regulatory authorities can test different monitoring equipment, system services and other production among 330 household and industrial customers. The primary aim is to develop commercial products and services suitable for the smart grid of the future, but also consumer-oriented efforts, enabling increased value as well as reduced costs. In Smart Energi Hvaler all the 6,800 inhabitants of the municipality of Hvaler are included. All the inhabitants are customers of the distribution grid company, Fredrikstad Energi Nett, and have been offered new smart meters. Given that this infrastructure with new ICT is in place, this demo is focussing on how to develop and test systems that can both increase the efficiency of the grid companies and assess the consumption flexibility. This may also influence assessments of the need for developing and/or upgrading the grid infrastructure such as further development of the regional grid.

But is this sufficient in order to promote sustainable outcomes?

One of the first scholars to address electricity grids as merely a technical system was Thomas Hughes in his book about the development of electricity networks in the United States and Western Europe. Hughes (1993) points out that matured socio-technical systems tend to reinforce their own behavior, patterns and ways in which to formulate and solve problems. In that vein, system innovation would often require changes not only to technological setups, but also to markets, regulations, politics, and society, which, in turn, makes it difficult for the established actors and organizations involved to change their behavior. However, the last years have been marked by a more integrated European electricity sector – a breach with former ways of nationally organizing electricity transmission and grid development. The electricity systems are getting more complex and new actors that try to influence the established actors and institutions have emerged. The efforts undertaken by the demonstration projects of the Norwegian Smart Grid centre clearly indicate that new and more cross-cutting solutions are necessary, but recent changes have also been directly related to the exogenous shock in the beautiful Norwegian Hardanger fjord. The 'monster-grid debate' triggered the government to prepare a new grid policy white paper (meld.St 14 2011–2012), which was later unanimously approved by the Norwegian Parliament. In the white paper, policy procedures with respect to the central grid have been revised so that actual requirements of the system need to be addressed more systematically. Besides, the solution opted for by the grid company has to be assessed by a third party and the proposed and assessed alternative solutions must then be approved by the government before the grid company can subject a specific project to the licensing application – including impact assessment. A major concern after the 'monster-grid debate' and emphasized by both the EEGI as well as the Norwegian smart grid initiatives are public barriers related to customer engagement and public acceptance of infrastructure developments.

It is thus particularly relevant to examine how economic, environmental and social dimensions, at multiple levels or scales of activity, are addressed and negotiated within current grid-development regimes that are undergoing changes both locally and centrally. The reason is also related to the simple observation that many smart grid efforts like the EEGI – despite the rhetoric and stated objectives – do not necessarily take into account structural variables conditioning the degree of inertia in dominant energy systems (what we referred to as path dependence), as well as contextual variables conditioning the integration of renewables in a specific regional–local setting, or path creation (Lafferty and Ruud, 2008).

In fact, the notion of sustainable development stresses the need to integrate economic, social and environmental concerns at different levels, from the local to the global. Thus, when discussing the sustainable development of electricity grids we need to consider not only how particular projects take those dimensions into account at a certain level, but also how the whole grid development *regime* functions and how those dimensions and levels of impact are discussed and included in it. In other words, a sustainable grid-development regime should also take into account the political dimension of sustainability (Lafferty et al., 2008).

There are critical issue areas that require a trade-off, but the political dimension of sustainability relates to how economy, welfare and ecology are treated simultaneously, and how the three pillars of sustainable development are prioritized in strategic decisions related to grid development. A proper balancing of the three is the only way of promoting sustainable grid development. The question is: How is this balance achieved?

How is sustainable grid development promoted?

Let us now discuss each of the above dimensions more closely. Regarding environmental concerns, a sustainable grid-development regime must not only take into account international and national needs and demands for a transition towards renewable energy, but also articulate local environmental concerns and needs, as regarding the preservation of local fauna and flora. Thus, it is crucial to examine whether and how grid-development regimes simultaneously include concerns and measures to address those different types of environmental impacts at different governance levels. In fact, several studies have demonstrated that ‘visual impact and landscape intrusion are by far the most important factor’ (Toke, 2005) in shaping responses to large-scale energy infrastructures, such as wind farms or high-voltage power lines.

When it comes to the social concerns of sustainable grid-development regimes, we need to consider several different levels of impacts and legitimacy for the development of electricity grids. Besides the legal and institutional frameworks supporting the deployment of new high-voltage power lines, and the tendency for the diffuse general support of citizens towards both renewable energy generation and new transmission lines (Bell et al., 2005), support and legitimacy of new grid developments are necessary both at regional and local levels, as these are the ones more directly impacted (Assefa and Frostell, 2007). In other words, it is crucial to consider the publics’ and communities’, as well as other stakeholders’ acceptance of grid developments and thus of both the short- and long-term perceived legitimacy of such developments. This is as relevant for the development of the distribution as well as the central net, but also for the development of smart grids.

Finally, the economic dimension also has to take into account the multiple levels of governance or impacts, and the social and environmental dimensions of sustainable grid-development regimes. Economic efficiency needs to be defined according to the different levels involved – economic benefits at a national or European level do not necessarily outweigh costs at the local level, as local protests could reduce the long-term economic efficiency even at other levels. In other words, economic sustainability implies that besides weighing economic costs and benefits, social and environmental dimensions must be considered as well – otherwise grid developments risk becoming more costly if they are contested and therefore delayed, postponed or withdrawn altogether.

To sum up, more sustainable grid development must be rooted in a grid-development regime that takes into account the economic, environmental and social dimensions of grid development at different levels – international, national, regional and local – throughout the different phases and stages of grid development – planning, design, siting, licensing and installation – in an integrated and balanced way. This goes beyond the EEGI approach of promoting smart grids. A more sustainable approach means that optimizing benefits at one level or in one dimension could easily result in overall sub-optimization due to conflicting concerns at different levels. An optimizing strategy centres on a notion that if the organizational parts or subunits in a system operate optimally, the whole organization or the full system functions optimally. This may also be an approach for those promoting smart grids but, in line with the argument of Simon (1957), this will not necessarily be the outcome. The system or organization must examine the interactions between subunits and their relation to the overall objective of the system or organization. A grid-development regime can be accordingly analyzed as a system consisting of several subsystems such as local involvement, integration between government levels, planning efforts, implementation phases and so forth. Based on the perspective of sub-optimization, in line with the reasoning of Simon (1957) we may suggest that optimizing the outcome for a subsystem in a GDR will in general not optimize the outcome for the system as a whole. He argues that optimal solutions are not relevant because a fully rational decision-making process is difficult due to limited information, time-limitations and so forth. He therefore argues in favor of a bounded rationality wherein the *optimizer* is a *satisfier*, implying that a decision-maker who is satisfied with a reasonable solution does not look for the optimal solution. The question is whether such a satisfying approach is acceptable for those concerned with promoting a smart grid?

Satisfying bounded interests and concerns – also a governance challenge

A socio-technical system develops along certain paths or trajectories that incrementally improve the way the system operates or, in other words, the existing system logic that also creates path dependency (Lafferty and Ruud, 2008). With the smart grid the question is whether a focus merely on techno-market concerns is sufficient to produce sustainable outcomes? A mature, path-dependent system tends to focus on optimization rather than on system innovation and path creation because everything is streamlined according to the existing socio-technical system setup (Arentsen et al., 2002). This makes it difficult for the established actors and organizations to change their behavior – despite the prevailing rhetoric of promoting smart grids. Trying to change such an existing trajectory is often met with considerable resistance. This situation has been called a 'techno-institutional lock-in' which can lead to persistent market and policy failures due to the persistent incentive structure that supports the existing trajectory (Unruh, 2000).

The systematic behavior and interconnectedness of different socio-technical elements are usually beneficial in the beginning of a trajectory if they solve a societal problem, but when overly matured as in the way electricity grids have been justified and developed, such systems prevent the development of more optimal solutions and trajectories – what we refer to as more sustainable pathways. The question that I raise in this chapter is whether the promotion of smart grids, as represented by the EEGI initiatives, represents a feasible and satisfying solution. Efforts related to the techno-market approach may be necessary, but without a more proper handling of contextual variables it may easily become insufficient and unsustainable in promoting development of distribution and transmission electricity grids.

Looking at the Swedish electricity system, Högselius and Kaijser (2007) pointed out that after a long period of socio-technical system optimization characterized by strong growth and eventual saturation, a system change can be triggered by the 'socio' part of the system, for example through electricity-market reforms, deregulation, international expansion and so forth. (Högselius and Kaijser, 2007). In the case of Sweden this change in the 'socio' category occurred during the same period as Sweden underwent an economic crisis, which suggests that system landscape factors – the context – can be important triggers in reforming an existing regime.

How can this be perceived? To illustrate the challenges of promoting smarter solutions, let us dig somewhat deeper into grid-policy practices in Northern Europe – particularly Norway and Sweden, as this may illustrate current challenges in line with the techno-market approach of addressing contextual variables. The focus on grid-policy practices in Norway compared to Sweden may illustrate current challenges of promoting more sustainable outcomes – also related to energy security at large, far beyond Northern Europe.

Grid policy practices in Norway

Norway was among the first countries to develop a local power grid, and Hammerfest became the first city in Europe with electric street lighting (1891). However, the central grid was not fully developed until the 1980s. The grid system was mainly built *from below,* stemming from regional and local initiatives. This is due to geographical, topographical and political factors (Angell and Brekke, 2011). Norway's river system is varied and geographically diverse. The establishment of small local power plants was technically feasible and affordable, also at the local political level. Therefore, Angell and Brekke (2011) argue that the Norwegian power system is characterized by a certain local embeddedness, where hydroelectric power traditionally has been produced *and* consumed locally. Still, almost 99 percent of Norwegian energy use stems from hydropower,[8] and the power plants are spread out over most of the country. This has affected the system for grid development, where the need for a long-distance central grid has been of minor importance. As we will see below, this stands in stark contrast to Sweden. The Norwegian central grid was based on local transmission grids, and facilitated by the power system operation – the 'Samkjøringen',[9] an association of local hydropower companies. The coupling and linking of local and regional transmission grids started as late as in the 1960s, and was not fully linked until 1989.

The local embeddedness of the power system has continued throughout the post-war period, in contrast to in most other countries. Norwegian local embeddedness and the decentralized hydropower structure were first challenged when the global liberalization and de-regulation regimes emerged in the 1990s. However, unlike in many other countries, the 1990 Norwegian Energy Act was not conducive to privatization. The hydropower companies, which until 1990 in most cases were owned by municipalities and counties, became publicly owned limited companies. Hence, Angell and Brekke (2011) argue that the Norwegian Energy Act was conducive to a *decoupling from the political level*. Further, the Energy Act produced *organizational concentration* through mergers into larger regional power companies. As a consequence of the Energy Act, in 1991 the Norwegian Parliament decided to establish Statnett.[10] This is a state-owned enterprise whose purpose is to own, run and develop the central grid. Today, Statnett owns 87 percent of the central grid, and is responsible for the project that caused the 'monster-grid debate' in Hardanger.

Are grid policy practices in Sweden different?

The Swedish river system is characterized by larger and more concentrated rivers, which were more capital intensive to exploit than the Norwegian rivers (Thue, 1995). Accordingly, the state became important in the development of the Swedish hydroelectric power system, especially in the pre-war period. This hydroelectric power system is characterized by large distances between production sites and final consumption. Consequently, the state also became responsible for grid development. This happened as early as the 1920s.

The Swedish state's engagement in hydroelectric power and grid development was mainly building on the state-owned company Vattenfall, which was founded in 1909. Already by 1938, the country was connected through a national grid, and from 1947 Vattenfall also became Sweden's transmission-system operator (TSO) (Jakobsson, 1996). As in Norway, municipal electricity boards have historically administrated local electricity distribution. By 1950 there existed approximately 5,000 electricity-distribution companies in Sweden. Today, 175 companies still exist, most of them organized as limited companies. Although the global tides of de-regulation and liberalization also swept across Sweden, the changes came late and they did not really challenge the existing system. The Swedish Energy Act was concluded in 1996, after a process whereby Vattenfall was transformed into a limited company (1992), and where the transmission-system operation was transferred to the new institution named Svenska Kraftnät (Högselius and Kaijser, 2007). Svenska Kraftnät was established in 1992 in preparation for the forthcoming de-regulation implied by the Swedish Energy Act of 1996. Svenska Kraftnät is now a state-owned enterprise, which administers the central grid and serves as TSO.

Since the early 1970s, electricity production in Sweden has more than doubled, partly because of the introduction of nuclear power in the 1980s. Since 1985, production has maintained a steady level of around 145 TWh/year. The majority of power comes from hydropower (46 percent), nuclear (38 percent) and conventional thermal power (13 percent), but in the last decade, wind-power production increased substantially. Parliament has set high climate-policy goals, including a target of 30 TWh of wind power by 2020. As a consequence, Svenska Kraftnät has argued for extensive grid investments in the following years. Currently, Sweden and Norway are part of a joint certificate system which also creates a kind of Nordic championship for efficient licensing procedures related both to grid as well as generation projects. Thus, let us dig somewhat deeper into concession practices, as they also highlight a core source of conflict, the actual assessment of needs for why such a grid project should be realized.

Concession practices and licensing system arguments for grid development and needs assessment

The process of licensing and concession are institutionalized practices which seek to give voice to different interests. The object is to counterbalance and reconcile interests and actors.

The actual licensing procedures in Norway

A concession ('anleggskonsesjon') is required for grid-development projects over 22kV. According to the Norwegian Energy Act, the concession process has to take place in a socially appropriate and rational manner, including considerations regarding private interests and the general public (The Norwegian Energy Act, §1–2). The process of granting a license starts when a grid developer sends a notification to the Norwegian Water Resources and Energy Directorate (NVE). The directorate manages and administers hearings and consultations. The NVE also defines a program for consequential analysis, including an environmental impact analysis (EIA). Both consultations and the EIA within the Norwegian GDR are arranged and managed by the NVE. Hence, the Norwegian GDR is characterized by the fact that it is facilitated by the central government.

When the consequential analysis is reported, the developer can submit an official application, which is discussed and approved by the NVE. Throughout this process, NVE arranges hearings and meeting in the local communities where the grid is to be built. The NVE then makes a decision, but most projects are appealed to the government. The scope of the appeals procedures varies, but often takes the form of a new investigation, including new inspections and new consultations, if necessary. This practice, whereby most cases are appealed and whereby the government has to conduct new investigations and inspections, is a lengthening factor for the concession process in Norway. This is also an important reference for the changes that recently have been made. Finally, after a license is given, the developer has to make a more detailed plan wherein the projected line is negotiated against the interests of local stakeholders and, in particular, landowners.

Brekke and Sataøen (2012) argue that the Norwegian licensing process incorporates a *paradox of participation*: the longer the concerned parties wait to get involved, the greater the effectiveness of participation. This is so for several reasons. First, to take part in the early stages of a grid project is time-consuming, while the benefits of participation are highly uncertain. It is often only when the grids have begun to materialize in the form of lines on the map – thus becoming more visible – that potential stakeholders can be identified and mobilized. Given that the appeals process often implies a full re-investigation, interested parties could choose to await mobilization until this stage. Committing oneself earlier could sometimes be counterproductive, as committing also means negotiating and compromising, while the end results could – as indeed they have in some cases – change dramatically in the appeals phase.

Although for many of the contested central grid projects in Norway there is substantial disagreement and conflicting interest, the acceptance and legitimacy of a grid-development project depend to a large extent on how the project is presented, communicated and negotiated locally and regionally in the early phases of the project. Therefore, the needs-assessment phase is important in order to ensure social acceptance of the necessity of grid-development projects. In Norway, the needs-assessment takes place *outside* the formal licensing process, and is highly expert-driven.

The major discussions about grid development take place within two planning processes: The National Grid Development Plan (NUP) and Regional Power System Reports (KSU). Power system experts within grid and power companies produce these documents, and the reports are seldom discussed in public nor are they made objects for political negotiation. Both reports describe the current power situation by focusing specifically on the grid system, future transmission conditions and expected investments and changes within the power situation. The authorities (NVE) play no role in these reports, except as recipient, and municipalities and local interests have limited access to the processes wherein the reports are discussed and written. Further, some parts of these annual reports are kept secret from the public due to safety regulations. In this situation, in which major investments and plans are discussed and negotiated within a limited sphere, the local embeddedness that historically has characterized the Norwegian electricity system is fundamentally challenged.

Simultaneously, there is a strong emphasis on improved models of communication between the concerned parties involved in promoting smart grids. Through smart metering, given access to more specific data, grid companies may better understand electricity-consumption patterns. Given the prevailing practices of grid planning, perhaps the reasoning of smart metering should be extended into enabling better understanding of political needs and priorities among the citizens impacted by grid development – such as those in Hardanger triggering the ‘monster debate’!

Is the GDR different in Sweden?

In its formal form the Swedish system for grid concessions does not differ significantly from the Norwegian. The phases and structure of licensing are similar, although they are given different weight. A specific grid project starts with a preliminary study in which the developer presents different alternatives for the grid line. Based on this preliminary study, consultations and hearings are arranged. This consultation involves municipalities, authorities, landowners, voluntary organizations, developers and so forth and is strictly regulated by the EIA law (Miljöbalken, 2009). The actual consultation shall discuss localization of the grid, its size, volume and scale, in addition to the project’s environmental consequences. A *consultation report* summarizes the different arguments from the consultations as well as the developer’s comments. In the light of the consultations, the developer chooses a specific line and location and describes this in more detail. In addition, an environmental impact analysis is made. This EIA is then the object for new consultations. In this process the county agency (Länsstyrelsen) has the authority to suggest alternative grid lines and can instruct the developer to arrange extended hearings. Local municipalities, in their turn, have a detailed planning monopoly in Sweden, which means that grid projects that are not adapted to this plan can be subject to delays in several municipalities at the same time. The county authority, in turn, is supposed to represent the national interests vis-a-vis the local municipalities. The county authority as well as the local municipality both underline the central role played by the regional level. After the decision is made by the county agency, the developer can submit a full application to the Energy Market Inspectorate, which arranges a further round of hearings. In the case of high-voltage national grid projects, or if some of the involved parties object to the project, the government makes the final decision.

What characterizes the Swedish GDR in comparison with Norway is the attention to consultation and dialogue. Consultations are arranged throughout all the different stages and phases of a project, from preliminary report via EIA to the final application. Another difference compared to GDR in Norway is the importance of the regional and local levels. The county governor administers the initial consultations and has an important say in the matter of environmental impact analysis. Further, municipalities have a ‘planning monopoly’, meaning that a grid-development project cannot act counter to a municipality plan. Thus, there is a strong incentive in the Swedish system to negotiate and consult *before* applications are fully developed and sent to the government. This consultative characteristic of the Swedish regime is, however, also a lengthening aspect of the process. While, in Norway, the post-application process (and the appeals process) constitute the lengthening factor, in the Swedish system the lengthening factor is the consultation aspect *before* application. In general, however, time spent is fairly similar to Norway, with a lead time of 5–10 years (Svenska Kraftnät, 2013).

Towards a smart and sustainable grid regime?

Whereas in Sweden the central grid was built by the state, the Norwegian central grid was based on the existing local and regional transmission grids. Historically, hydroelectric power is created locally and it is expected to be consumed locally as well. Stein Rokkan (1967) argues that the organized opposition from the periphery towards national standardization has been important in Norway. This opposition, interestingly enough, still seems to be an inherent part of the Norwegian GDR. The energy acts of the 1990s unfolded differently in the two countries, as well. The Norwegian Energy Act caused an organizational concentration where larger regional power companies became dominant. The Energy Act also resulted in a decoupling from the political level where power professionals within the electricity companies became influential. Swedish liberalization came later, and the consequences have been less radical, but also led to regional concentration on the power-generation side. Accordingly, Norwegian and Swedish grid-development regimes can be characterized as two different historical models, but in both there are current needs for encompassing a smarter grid – also in terms of improved dialogue and coordination among concerned stakeholders.

When it comes to the actual concession practice there are several similarities between the two countries. Consultation policies are fairly similar, a consequential analysis must be included in all applications, and a specific authority for concessions handles the applications. The statutory parties involved in a concession process also roughly correspond to each other in both countries, and the concession practices are somewhat extensive and time consuming.

However, the GDRs have different central points. The Swedish system is characterized by consultation and deliberation, and there is an emphasis on the regional and local level in the concession practice. In Norway municipal plans have more weight and are more binding than local energy plans. Also, the Swedish EIA process can be extended by the county authority, which again increases consultation. This forces the developer to take into account local needs at a *pre-application* stage, whereas in Norway, much of the participation really happens *after the application* stage. This is also related to the fact that the rather technical procedures around the KSU – to assess actual needs, are not treated and approached politically in Norway. It is also interesting that in Sweden the EIA itself is organized by the developer, whereas in Norway a national authority carries out the process. Usually the EIA that is part of all the countries' concession processes is an important opportunity to anchor sustainability on a local level, and the way it is organized will impact the overall sustainability of the GDR. The regional level in Sweden is important through its role as facilitator between local and national interests and in that form does not exist in Norway. Compared to Norway, the environmental and social aspects of sustainability are stronger in Sweden when looking solely at the local level, whereas in Norway the emphasis is on the national optimization of the process.

The national needs assessment in the Norwegian system is highly expert-driven and the lack of national political accountability in the early phases of needs assessment is conspicuous. In Sweden the publicly owned developer has to present its investment plans and corresponding budget to the parliament and, as such, is politically somewhat accountable.

The national social sustainability dimension is stronger in Sweden as the needs assessment is closely tied to the political process due to budget needs. The Norwegian TSO operates independently of the state budget in terms of capital requirements. When it comes to the national environmental sustainability dimension in Sweden, the conversion to more renewable energy has figured prominently on the political agenda. Renewable energy arguments are stronger in Sweden than in Norway, not least because of the Norwegian electricity mix, which mainly consists of renewable power. As such the environmental sustainability of a grid project is much more important on the local level in Norway, but far less so on the national level. Perhaps as a consequence of insufficient social and environmental sustainability on the local level, the practise in Norway is that most cases are appealed, with the government having to conduct new investigations and inspections. This is a lengthening factor for the concession process in Norway. As discussed, the lengthening factors in the Swedish concession system are rather the consultations *before* the application.

When the world is concerned with promoting smart grids as a way of promoting necessary grid expansions – hopefully in a sustainable manner – the experiences of Norway and Sweden clearly indicate a need to go more toward the Swedish experience. There will always be conflict, but by involving more stakeholders *before* application, the probability of realizing the project is higher. There are ever-stronger indications of the importance of addressing public acceptance when discussing energy projects. This is still not a concern for those advocating smart grids, but perhaps the experiences of Hardanger will remind the advocates that electricity consumers also are citizens. This is a reality far beyond Northern Europe.

Will recent changes in grid policy create sustainable changes?

In a white paper presented in 2012 by the Norwegian government, the concession process is defined as an obstacle and as inefficient, but with unanimous approval of the Norwegian Parliament, changes have been made to speed up the process. Identification of need shall be assessed, verified and politically approved prior to proposing specific projects. Besides, the regulator, NVE, shall only coordinate the licensing procedures and rather leave final decisions to the government. The ambition is that this will create better opportunities for substantive involvement from all interested actors in the decision-making process, but the question is whether this will speed up the process. Involvement must be substantial, in the sense that it must include both mutual obligation and influence. The consultations must also involve real dialogue. This might be time-consuming. Thus, it is still premature to know whether recent changes will speed up the process. The question is whether the new procedures really will create smarter solutions?

The licensing of the electricity grid is a process in which interests and actors are counterbalanced within and between different levels. The concession process is a practice seeking to give voice to different interests, at the same time as it attempts to realize national objectives and priorities. International concerns on renewables and climate are converted into national commitments that must be realized through local projects. The question is whether these local projects are perceived as local sacrifices and as costs that allow central political decision-makers to satisfy global needs. Currently, in Norway, changes are made so as to alter the planning procedures, but as long as local interests still feel that they are the ones making the sacrifices or paying the additional bills for so-called smarter solutions, it is unclear whether or not the actual procedures have been improved – at least in terms of enabling a speeding up of the process.

Achieving a more sustainable energy system relies upon a sensible and sound strategy for grid development, and it is important to go beyond the technical focus of smart grids. This is as relevant in Norway and Sweden as worldwide. The grid-development process takes time, but it can still be questioned as to whether current grid policies are promoting sustainable outcomes in which economic, social and environmental concerns are reconciled. The recent grid-policy decisions in Norway are making a difference because of an exogenous shock from the 'monster-grid' debate in Hardanger. We are on our way, but it is still somewhat unclear where we are going and whether it is the smart way. Let us hope that other nations do not need to await a monster debate before necessary changes to grid-development policies are made.

Notes

1. For further details, see http://www.statnett.no/en/About-Statnett/.
2. So dubbed by the Norwegian press because the area was of major scenic value and the power pylons perceived to be huge monstrosities ('monster pylons') ruining large swathes of pristine land.
3. The SusGrid project of CEDREN (www.cedren.no) studies the 'grid-development regime' in Norway, Sweden and the UK. The aim of the project is to provide better knowledge that can facilitate improved public acceptance enabling a more consensual realization of local grid projects, partly achieved through: improved planning tools enabling a better and more effective governance structure, new economic mechanisms promoting both 'smart' and sustainable grid development and new policy instruments enhancing communication and dialogue among stakeholders, citizens and the media.
4. For further details, see https://www.entsoe.eu/.
5. For further details, see http://www.edsoforsmartgrids.eu/.
6. http://www.smartgrids.eu/European-Electricity-Grid-Initiative.
7. For further details (Norwegian only), see http://smartgrids.no/.
8. http://www.regjeringen.no/en/dep/oed/Subject/energy-in-norway/Electricity-generation.html?id=440487.
9. Until 1970 there were several regional amalgamations coordinating central grid initiatives. In 1970 these were merged into one national 'samkjøring', or grid system operation (Brekke and Sataaen, 2012).
10. Royal Proposition (St.prp. nr. 100 (1990–1)).

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Part III

Energy and Politics: Solutions and Policy Frameworks

10

A Review of Renewable Energy Legislation and Policies in China

Yu Wang

Introduction

As a newly emerging industrial nation with a large population, China has experienced rapid growth both in terms of economic output and energy consumption, especially during the last decade (Figure 10.1). Although China's government, in its 12th Five-Year Plan, announced the goal of keeping annual economic growth rates below 7 percent (China's State Council, 2011), energy demand is projected to increase over the next two decades, driven by a highly energy-intensive economy and by strong GDP growth (Cherni and Kentish, 2007).

Furthermore, the coal-dominated energy structure is also significantly contributing to environmental pollution and global warming. The share of

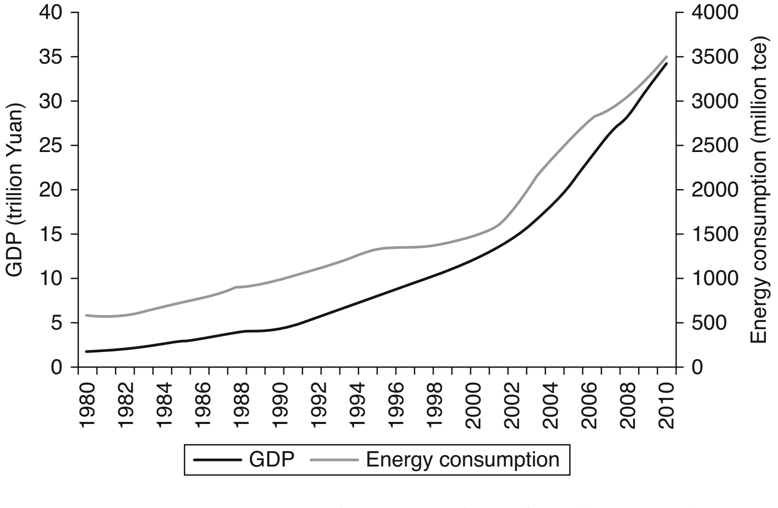


Figure 10.1 Energy consumption and GDP growth in China (1980–2011)

Source: China Energy Statistical Yearbook (2012).

coal in energy consumption has decreased by 8 percent, but it still represents almost 68.4 percent of total primary energy consumption. Although the share of non-fossil energy has increased from 5.1 percent in 1990 to 8.0 percent in 2011, more than 80 percent of this came from hydro power (Figure 10.2).

As sustainable and clean energy derived from natural sources, renewable energy has a potentially important role in increasing electrification levels, thereby protecting the environment, guaranteeing energy security, and providing for economic and social needs (Tsai and Chou, 2005). In order to encourage and provide incentives for renewable energy development, China's government has issued a set of policies and measures, including general target setting, financial incentives, and pricing mechanisms. This chapter will trace policy-making, the resulting development of renewable energy, and evaluate the effectiveness of these policies.

This chapter is set out in the following way: first, it maps the stakeholders involved in renewable energy development and management on both the macro and the micro levels; then it describes the framework of renewable energy legislation, policies and measurements, and analyzes the reasons for amending the old version of the Renewable Energy Law and the policy system; third, it evaluates the effects of current renewable energy policies. The final section describes the barriers facing further renewable energy development in China and presents policy recommendations for overcoming these barriers.

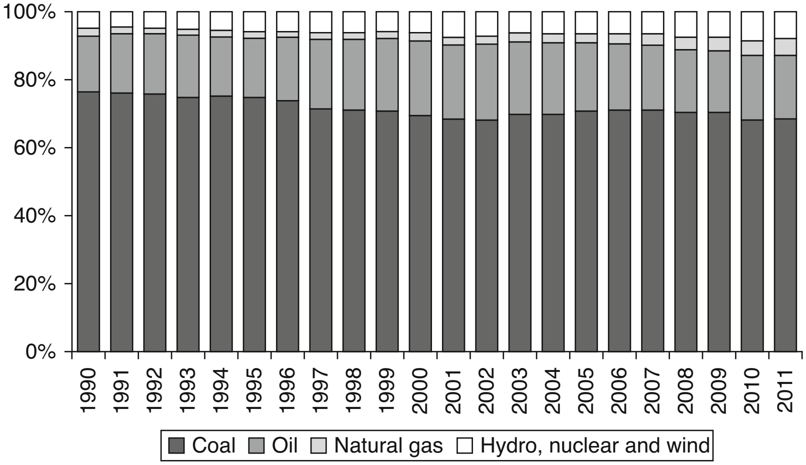


Figure 10.2 Total energy consumption in China (1990–2011)

Source: China Energy Statistical Yearbook (2012).

Renewable energy management system

In China, the management system for renewable energy is characterized by a combination of centralized administration combined with decentralized administration of practical implementation at local levels by the requisite departments (Li, 2008; Wu et al., 2008; Xia et al., 2011). As the administrative department responsible for renewable energy, the National Energy Administration (NEA) and National Development and Reform Commission (NDRC) assume the responsibility for setting medium- and long-term total volume targets for renewable energy throughout the country, compiling national renewable energy development and utilization plans, and publishing the Guidelines for the Renewable Energy Industry Development. A chart of the main administrative organizations can be seen in Figure 10.3.

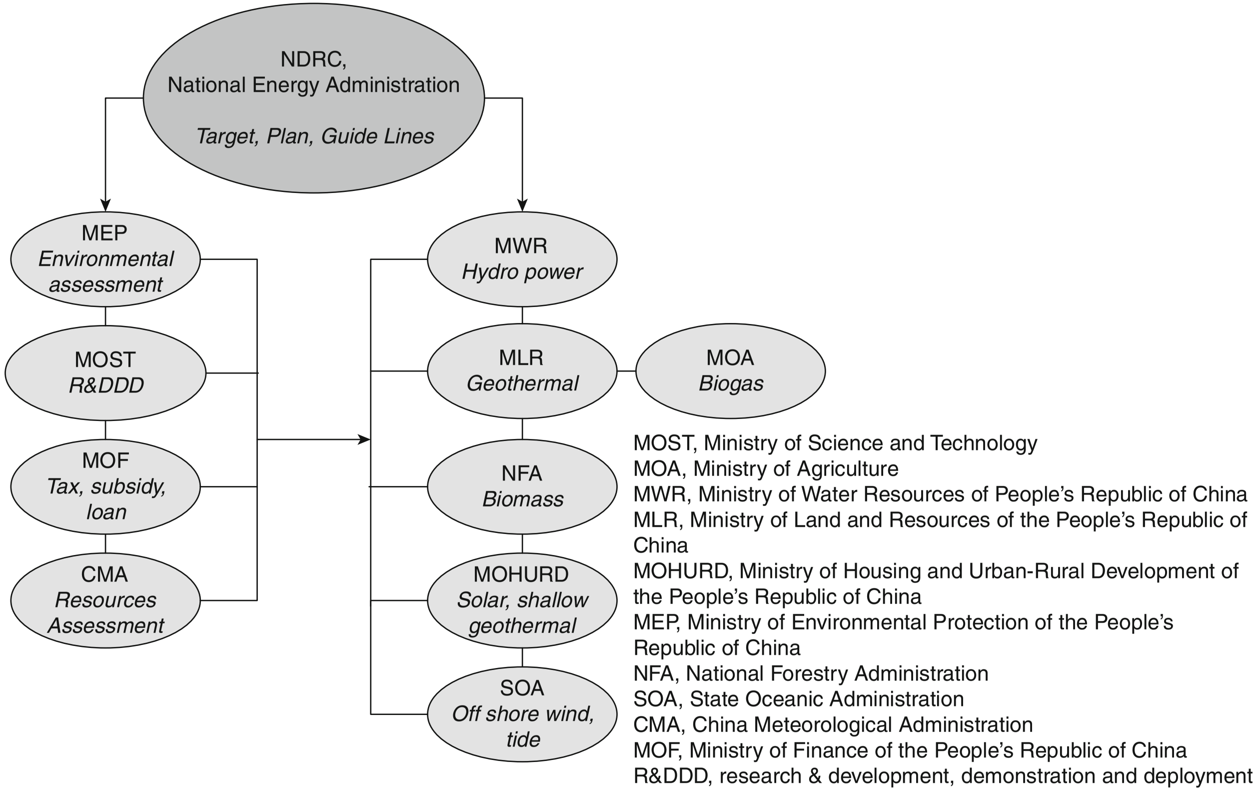
Due to the complexity of renewable energy resources, technologies and utilization, many ministries and departments are involved in the managing of renewable energy. Departments such as Ministry of Science and Technology (MOST), China Meteorological Administration (CMA), Ministry of Environmental Protection (MEP), and Ministry of Finance (MOF) mainly focus on the research and development, demonstration and deployment (R&DDD); wind and solar resources assessments; environmental assessments; and financial incentives of renewable energy deployment. Departments such as the Ministry of Water Resources (MWR), Ministry of Land Resources (MLR), National Forestry Administration (NFA), Ministry of Housing and Urban–Rural Development (MOHURD), and the State Oceanic Administration (SOA) are involved in the management and development of various types of renewable energy.

Although the National Energy Administration has centralized the administration of renewable energy, the practical management of renewable energy is still decentralized and localized. For example, wind farm developers have to get approvals from both the resource management department, MLR and CMA, and the energy management authority, NDRC. The complex management system results in low efficiency and high hurdles for renewable energy enterprises and investors.

Laws, policies and actions related to renewable energy

Renewable energy legislation

Renewable energy was first mentioned in the 'Electricity Law of the People's Republic of China' published in 1995, which stated that 'the state encourages and supports electricity generation by using renewable and clean energy resources' (China's State Council, 1995). Nonetheless, no concrete measures were mentioned. In 1997, the 'Law of the People's Republic of China on Energy Conservation' clearly stated 'the state encourages and supports the rural areas in their great effort to develop methane, spread the application of the



MOST, Ministry of Science and Technology
MOA, Ministry of Agriculture
MWR, Ministry of Water Resources of People's Republic of China
MLR, Ministry of Land and Resources of the People's Republic of China
MOHURD, Ministry of Housing and Urban-Rural Development of the People's Republic of China
MEP, Ministry of Environmental Protection of the People's Republic of China
NFA, National Forestry Administration
SOA, State Oceanic Administration
CMA, China Meteorological Administration
MOF, Ministry of Finance of the People's Republic of China
R&DDD, research & development, demonstration and deployment

Figure 10.3 China's renewable energy management system map technologies for utilization of such renewable sources of energy as biomass, solar and wind power, small-scale hydro power generation'. This clarified the development direction of renewable energy (China's State Council, 1997).

In 2005, China's State Council published the 'Renewable Energy Law' (REL), which provided a single, coherent framework of government policy for the development of renewable energy, this law came into effect at the beginning of 2006 (China's State Council, 2005). The REL instituted five market interventions: setting an overall target for renewable energy production, mandating compulsory grid connections, introducing a feed-in tariff (FIT), cost-sharing for electricity generated from renewable energy, and establishing a special renewable energy promotion fund (Wang et al., 2007). The signals that were sent through these measures were positive national incentives for renewables development. Moreover, by setting explicit renewable-capacity targets the scale of the market was guaranteed.

Renewable energy has developed rapidly in China since the implementation of the REL. By the end of 2006, the utilization of renewable energy was about 200 million tce (tons of coal equivalents), not including traditional biomass utilization. Hydropower accounted for a capacity of 125 GW, with an additional 2.6 GW of wind power, 360 MW of solar power, and 100 million m^2 of solar water heaters. Furthermore, the implementation of the REL induced both global wind-turbine manufacturers and domestic-grid companies, power generators and energy companies to enter the market. Almost all the big global wind-turbine manufacturers invested and built factories in China, which resulted in the formation of a renewable energy equipment-manufacturing industry (Li, 2007).

Nonetheless, the rapid development of both manufacturers and developers was beyond what was anticipated when the law was enacted, meaning that the REL could not keep up with the pace of renewable energy development. So, in 2009, an amended version was enacted to respond to the new emerging demands of renewable energy (China's State Council, 2009). In the new version of the REL, some of the remaining problems were addressed. Compared to the 2006 version, the 2009 version mainly addresses the following aspects of renewables.

Formulating a more scientific approach to renewable energy planning

The new REL highlighted the importance of increasing the use of science-based planning tools when making large-scale plans for the development and utilization of wind, solar, water, biomass, geothermal, ocean and other renewable energy so that these are coherent within the framework of the national energy system. Additionally, the need for coordination between regional and national government for renewable energy planning was also mentioned in the new REL in order to help guarantee an efficient allocation of resources. Elements such as setting targets, regional network design and construction, service systems, and safeguards were reflected in the plan.

Power grid connections – quotas for electricity generated from renewables

The new REL clarified the delineation of responsibility among the state, grid enterprises, and electricity generating enterprises. At the top level, the state determines the share of total electricity to be generated from renewable energy, and guarantees that electricity generated within this target by renewable energy producers will by purchased in full. In order to reach this target, the NEA and the State Electricity Regulatory Commission (SERC) defined the responsibilities of grid companies and power generators to implement such measures.

At the industry level, grid enterprises should sign grid-connection agreements with renewable energy electricity-generation enterprises to ensure that all renewable electricity generated in their region is purchased in full. Additionally, grid enterprises should take responsibility for synchronizing this electricity with the rest of their grid. On the other hand, electricity-generating enterprises need to meet the grid connection technical standards of the power grid, and have to cooperate with the power-grid enterprises in protecting grid stability.

Renewable energy subsidies

The new REL also enhanced financial incentives for renewable energy development, emphasizing that 'for the access cost and other relevant costs that cannot be recovered from the selling price of electricity, the power grid enterprises can apply to the renewable energy development fund for subsidies (China State Council, 2009)'. Specific measures for the administration, collection, and use of the renewable energy development fund shall be formulated by the public finance department of the State Council together with the energy department and the price department of the State Council. Although a renewable energy surcharge of CNY0.001/kWh was set from the nationwide sale of electricity with the goal of supporting renewable energy development (NRDC, 2007b), this amount has proven insufficient to the subsidies mandated by the REL because of the fast development of renewable energy. The renewable energy surcharge was increased to CNY0.004/kWh, with a total CNY10 billion of renewable energy surcharge collected in 2010, which only covered 70 percent of the subsidy needed. Since the beginning of 2012, the renewable energy surcharge has been further increased to CNY0.008/kWh, although this level is still inadequate. According to one forecast, a renewable energy surcharge of CNY0.012/kWh is required to cover the subsidies needed for the development of renewable energy power generation (China Scope, 2011).

Overall targets of renewable energy development

There are three overall targets for renewable energy set by the central government, including the Mid- and Long-Term Plan for Renewable Energy

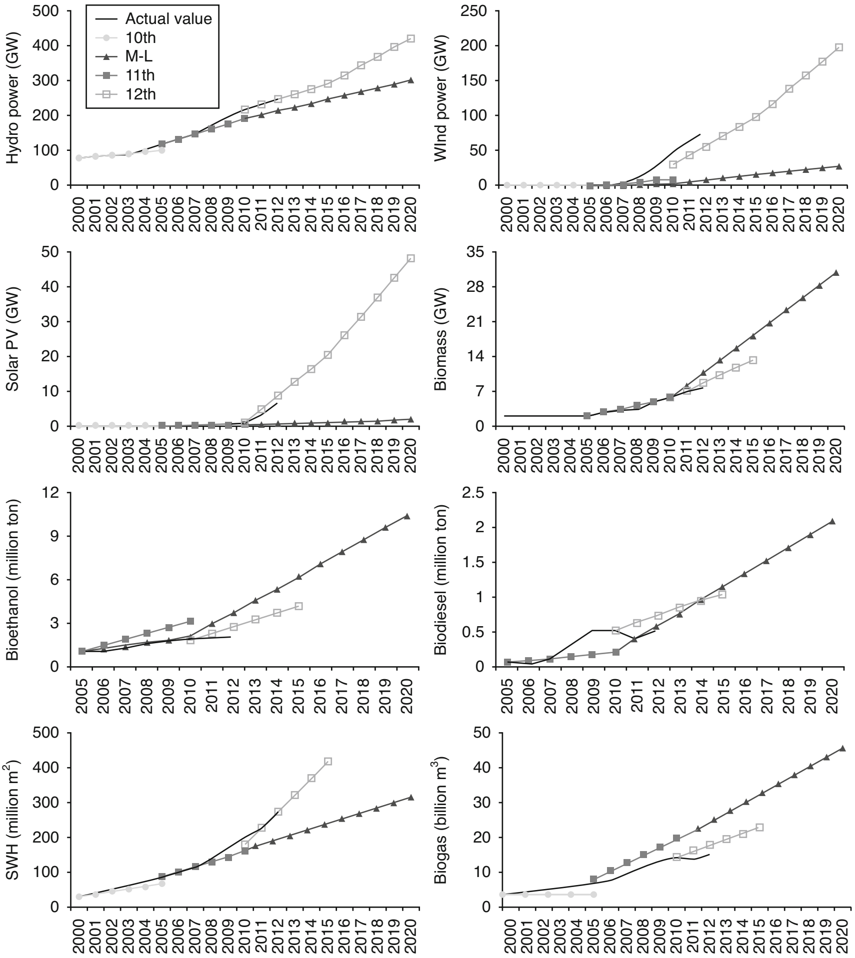


Figure 10.4 Comparisons of central government targets and actual capacity growth of renewable energy

Notes: 10th, 11th, and 12th mean targets in the 10th, 11th, and 12th Five-year Plans for Renewable Energy Development; while M-L represents the target set in MLTPRED; SWH means solar water heater.

Sources: MLTPRED, EFYPRED, TFYPRED (NDRC [2007a, 2008, 2012])

Development (MLTPRED) (NDRC, 2007a); the Eleventh Five-year Plan for Renewable Energy Development (EFYPRED) (NDRC, 2008); and the Twelfth Five-year Plan for Renewable Energy Development (TFYPRED) (NDRC, 2012). The gradually more-ambitious targets can be seen in Figure 10.4.

In the MLTPRED, the Chinese government set a target that renewable energy consumption should account for 10 percent of total energy consumption by 2010, increasing to 15 percent by 2020. But this target was reformulated by former Communist Party General Secretary Hu Jintao in September 2009 in advance of the COP 15 meeting in Copenhagen. He announced that the share of non-fossil energy would grow to 15 percent of total primary energy consumption, including not only renewable energy, but now also nuclear power.

If we break down this overall target, we can see differences between the four plans. The targets for all renewable energy technologies, except for biomass (including biomass electricity generation, biogas, and biofuel), were increased in successive plans. This means that almost all renewable energy development exceeded expectations, so that the targets had to be adjusted upward to account for the rapid growth of renewable energy.

Here we can see that increases in the targets for hydro power and solar water heaters are only very small, because hydro power and solar water heaters are already mature and widely used technologies, so there is little room for large increases in the future. The large differences between the 12th Five-year Plan targets and previous targets reflect the technological and market breakthroughs of wind power in China. Wind power installation reached 31 GW in 2010, which already exceeds the MLTPRED for 2020 (30 GW), reflecting the rapid development of wind in China (CWEA, 2010; Li, 2012). A similar trend can be seen in solar PV, although solar lags wind power by about five years, because of less-developed technological state and higher costs of PV compared with wind power. Almost 95 percent of PV modules produced in China were sold to Europe and the United States, and the Chinese government has come to encourage development of the domestic PV market in order to address the huge capacity of Chinese PV manufactures. China keeps raising the national goals for solar PV installation, the ‘12th Five-year Plan for Solar Power Development,’ released by China’s NEA set a goal of achieving 21 GW by 2015 (NEA, 2013b), and the goal was further raised to 35 GW by China’s State Council in 2013 GW (Solar Be, 2013; State Council of China, 2013).

In contrast with other types of renewable energy, biomass development fell far below the expectations of government plans. Total biomass utilization, including electricity generation, biofuel, and briquette fuel, will reach 50 million tce in 2015, according to TFYPRED, far lower than former targets. The decrease of biomass targets reflects the fact that the central government has recognized the difficulty of collecting agricultural and kitchen waste on a large scale, and that related industries face technical bottlenecks.

In conclusion, an overall target mechanism was mandated by the REL and was subsequently adjusted upwards on several occasions (for instance, wind and PV solar) in response to the actual development of renewable energy. Through the overall target mechanism central government could transmit positive signals to investors and developers, and at the same time guarantee the scale of the market for renewable energy.

Renewable energy pricing institutions

Government pricing and guidance pricing (price standard form by the price administrative department under the State Council in accordance with the tender price determination) were both introduced into the renewable energy pricing system at the early stage of renewable energy development. At present, almost all renewable energy, except for large-scale hydro power, is uncompetitive compared with conventional coal-fired power plants, which means that the government needs to set a price mechanism that reflects the externalities of all sources of energy (Zhao et al., 2011). With this background, the NDRC issued a document entitled 'Trial Measures for the Management of Prices and Allocation of Costs for Electricity Generated from Renewable Energy' (NDRC, 2006a), in which the prices of various renewable energy technologies and the allocation method of costs were set, and different pricing mechanisms were introduced for the development of renewable energy (Table 10.1).

For wind-generated electricity, the wholesale price is set based on the wind project bidding prices that emerge from a government-organized tendering process since the beginning of the Wind Concession Project in 2003. An FIT was also introduced from July 2009, in which the benchmark

Table 10.1 Pricing mechanisms for renewable energy

	Pricing	Comments
Wind, onshore	Concession bidding (from 2003) to FIT, Feed-in tariff (from 2009)	Different wind power prices were set according to local wind resources
Wind, offshore	Concession bidding/auction (from 2008)	
Biomass	Price subsidy to feed-in tariff/concession bidding	CNY0.75/kWh was set as the benchmark price for agriculture, forest biomass power; while CNY0.65/kWh was set as the benchmark price for municipal solid waste power generation
Solar PV	Government pricing + concession bidding to feed-in tariff in some provinces (from 2013)	Different PV power prices were set according to local solar resources
Oceanic power	Government pricing	Set by the government according to the rule of reasonable cost plus reasonable profit
Geothermal	Government pricing	

onshore on-grid wind-power prices were set from CNY0.51/kWh to CNY0.61/kWh depending on the specific resource area (NDRC, 2009). For offshore wind power, pricing was still based on concession bidding. However, the ultra-low price of the four 2010 projects has been blamed as a faulty bidding process. The lowest bid price was CNY0.6235/kWh, only slightly higher than high-end onshore wind-power prices; while the price of China's first offshore wind-power project was set at CNY0.978/kWh. The low bid price reflected overly optimistic forecasts on the part of developers regarding both national incentives for offshore wind development and large-scale cost decreases in the future. This, in turn, is the result of the lack as of yet of established pricing and subsidy policies for offshore wind power.

For biomass, during the early phase, the government mandated a subsidy of CNY0.25/kWh (NDRC, 2006a). The subsidy did encourage biomass power development, but also resulted in inequitable development between various regions in China. The subsidy was too low for biomass power projects in central and western regions of China because of the low benchmark price of coal-powered electricity in those regions and the higher costs of the raw material. The government has implemented benchmark on-grid power pricing for agriculture and forestry biomass power generation projects since 2010. Newly built biomass power-generation projects of these types were the result of bids that uniformly met the benchmark on-grid power price of CNY0.75/kWh. For these types of bidding projects, the price cannot go higher than the established national benchmark price (NDRC, 2010). For municipal solid-waste power generation, the NDRC issued a special notice that set a price of CNY0.65/kWh (NDRC, 2012b).

For solar PV, the benchmark price was set to CNY1.15/kWh for projects approved before 1 July 2011, while it was decreased to CNY1/kWh for projects approved after that date. The benchmark price for projects located in Tibet was kept at CNY1.15/kWh (NDRC, 2011). The NDRC set lower benchmark prices ranging from CNY0.90/kWh to CNY1.00/kWh for ground-based PV system depending on different solar radiation intensity in various regions of China and CNY0.42/kWh of subsidy for distributed PV system since September 2013 (NDRC, 2013).

Due to the small scale of geothermal power and ocean power, there are no specific pricing policies for these as yet. Nonetheless, the central government has published Guideline for Encouraging Geothermal Development and Utilization to encourage the development of geothermal power, and price subsidies were an important pricing measure mentioned in this guideline (NEA et al., 2013a).

In conclusion, because the cost of renewable electricity generation is still significantly higher than fossil-fuel generation (Cherni and Kentish, 2007; Liu et al., 2011), both developers and their financial backers need incentives from the government to invest in renewable energy development so that they can compete with fossil fuel power plants on price for grid access (Feng et al., 2010).

China's renewable energy pricing gradually evolved from concessionary pricing to the FIT mechanism. We can also see that China's FITs, in turn, have evolved from technologically neutral flat tariffs to technologically specific, graduated tariffs, and/or to tariffs with digression factors. These adjustments are aligned with what has been identified by leading sources as best-practice FIT designs in Europe and other developed countries – that is, tariffs that vary according to technology, size, resource intensity, and the degree of technological maturity of the renewable energy projects eligible for FITs. This more-targeted approach improves the overall economic efficiency of the policy. Although China has adopted several pricing methods for technologies at different development phases, it has nonetheless realized some success. However, there is a still long way to go in order for renewable energy to reach commercial competitiveness in China (Wan and Yin, 2009).

Renewable energy subsidies

Renewable energy systems are favorable energy options because of their sustainable and emission-free characteristics; the main challenge they face is to reduce their price to a competitive level (Lund, 2009). Thus, subsidies play an important role in the establishment of renewable energy technologies and their market development (Hirschl, 2009). In China, the NDRC grants subsidies to operators of renewable energy projects to compensate them for their costs. A detailed subsidy plan is supposed to be reviewed on a semi-annual basis.

The REL establishes a long-term, stable subsidization system for setting up a public-financed fund for renewable energy development. The fund is built by charging consumers an additional CNY0.008 on every kWh of consumed electricity, and can be used in two forms (NRDC, 2006b). First, it can be issued as a grant. Recipients of such grants use the funds for renewable energy research and development. Second, it can be used to subsidize loan interest. Eligible renewable projects may obtain public funds to pay part of their loan interest.

Since 2006, eight instalments of subsidies have been distributed for renewable energy power-generation projects. According to statistical reports (see Figure 10.5), CNY8.5 billion of subsidies were granted for 48,438 GWh of electricity generated by renewable energy from November 2010 to April 2011(NDRC and SERC, 2012). From 2006 to the middle of 2011, thanks to a total of CNY32 billion in subsidies, the capacity of renewable energy installations increased from 1,414 MW to 39,313 MW, while the electricity generated increased from 1,044 GWh to 48,438 GWh (Figure 10.5).

On the one hand, huge subsidies have stimulated the development of renewable energy. China has experienced rapid development of renewable energy power installations, especially wind turbines. On the other hand, the

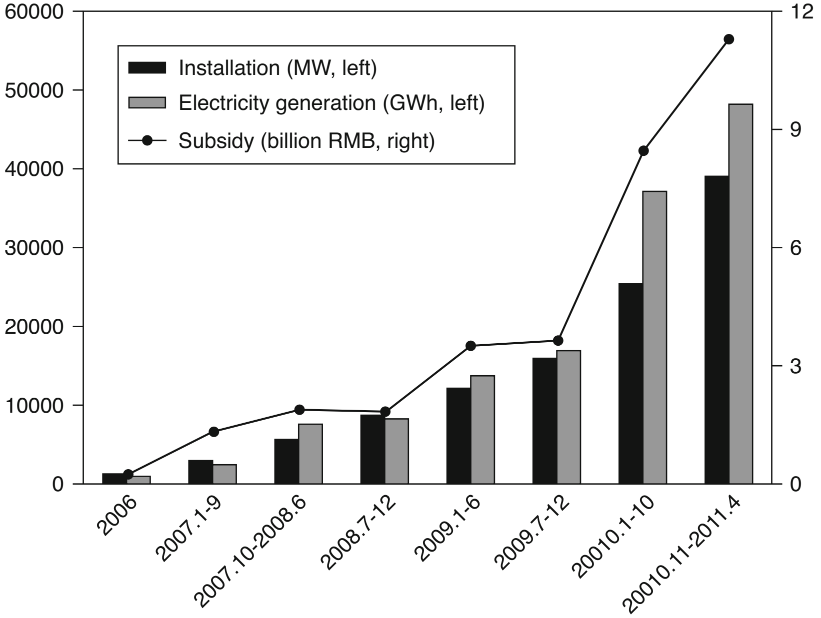


Figure 10.5 Subsidies for renewable energy projects
Source: NDRC and SERC (2012).

electricity producers received subsidies two years after their wind turbines were put into operation. For example, at the end of 2012, the NDRC's latest published report on the distribution of subsidies revealed a severe subsidy shortage from November 2010 to April 2011, which has had negative impacts on renewable energy developers and manufacturers.

More than 90 percent of distributed subsidies were granted for wind-power projects, which is consistent with the large share of wind power in China's renewable energy power market. The reason for this is that wind power is the most mature technology compared with other renewable energy technologies (except for hydro power), and needs more government support as it reaches the stage of commercialization.

Six percent of total subsidies were granted for biomass power generation. The share of biomass increased to 12 percent from the end of 2007 to June of 2008, but fell back to 7 percent at the beginning of 2011 (Figure 10.6). The change revealed the blooming of biomass power projects at the beginning of incentive measures' implementation, with a corresponding decrease because of a lack of sufficient raw materials and advanced technologies. The structure of renewable energy subsidies also reveals the relatively slow development of solar PV projects, and geothermal power projects, which took only 1 percent of total distributed subsidies.

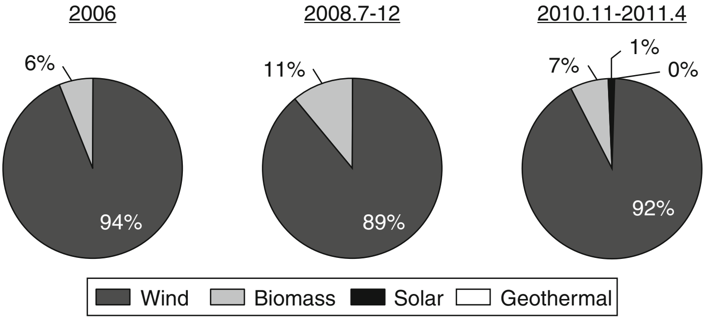


Figure 10.6 Subsidies for different types of renewable energy in China (2006–10)
Source: NDRC and SERC (2012).

Taxation policy

Tax incentives used to promote green electricity are mainly designed as tax exemptions, rebates on taxes, tax refunds or by applying lower tax rates on activities promoted. Not all available technologies are promoted, only those that reflect national priorities are promoted (KPMG, 2011). Value-added tax (VAT), corporate income tax (CIT), and customs duties are the three main categories of taxes in China. Up to now, various taxation policies have been issued to encourage renewable energy development, and the policies have been regularly updated to keep pace with the renewable energy development (Li, 2004; Zhang, 2013; Zhao, 2012).

Value-added tax (VAT)

At the end of 2008, the National Tax Administration (NTA, 2008a) published 'Circular on Value Added Tax Policy of Comprehensive Utilization of Resources and Other Products', and clarified that VAT paid on the sale of goods produced from recycled materials or waste residuals is refundable. According to the documents, a 50 percent refund of the VAT is paid on the sale of wind power, which means that the VAT for wind power was reduced from 17 percent to 8.5 percent. A 100 percent refund of the VAT is paid on the sale of biodiesel oil generated by the utilization of abandoned animal fat and vegetable oil and electricity generated by the utilization of waste, including municipal solid waste, crops, sewage, and medical waste.

Corporate income tax (CIT)

According to the 'Corporate Income Tax Law', corporate revenues earned by energy conservation and water-saving conservation projects, environmental protection and clean development mechanism projects are eligible for a three-year CIT exemption, followed by another three-year 50 percent reduction of the CIT rate for income derived from qualified projects, starting from the year in which the first revenue is generated. Applicable fields include biomaterial energy, energy cogeneration, the utilization of methane, and technological innovation in energy conservation and emission (NTA, 2008b).

Many enterprises engaging in renewable energy are considered as advanced- and new-technology enterprises. These can also be granted a reduction in the CIT. Usually the CIT rate is 33 percent, whereas advanced and new technology industries are eligible for a rate of 15 percent. Applicable fields include solar energy, wind energy, biomaterial energy, and geothermal energy (NTA, 2008c).

Furthermore, 10 percent of the amount invested in qualified equipment is credited against CIT payable for the current year, with any unutilized investment credit eligible to be carried forward for the next five tax years if such equipment is qualified as special equipment related to environmental protection, energy saving, or water conservation and production safety.

Customs duties

Customs-duty exemptions or reductions are also given to imported renewable energy power-generation equipment and to special items considered to be high-tech. According to the 'Import tax policy to encourage the development of equipment manufacturing industry', solar and wind equipment were included in the duty-free list. Large-scale wind power equipment and some solar PV equipment could be imported without tariff and value-added taxes, so as to stimulate Chinese renewable energy development. However, with the growth of domestic renewable industries, this policy has now been repealed (MOF, 2012). According to the new policy published by the government, wind turbines smaller than 3 MW have been removed from the duty-free list, which reflects the advance of domestic technologies.

R&D facilitation

Renewable energy research and development has received government support since the enactment of the 1993 Science and Technology Law, which included favorable accounting rules for the capitalization of research and development costs within high-tech institutions. Since 2000, national investments in renewable energy R&D took an average share of 15 percent of envisaged outlays in MOST science and technology-supporting plans. Wind power, solar energy, and biomass received priority public-investment support, accounting for shares of 40, 32 and 25 percent, respectively, of total investments in renewable energy technologies (Su et al., 2008).

R&D facilitation of renewable energy in China has come mainly from government science and technology projects, while industry has been less involved. One reason for this is that public investments mainly focus on R&D involving mostly universities and research institutes; while demonstration projects involving industry have been few. The other reason is a lack of R&D investment instruments on the part of industry.

Furthermore, low R&D investment in renewable energy also reflected China's low national R&D investment levels compared with most developed countries. So, China's incentives to promote renewable energy are not enough to propel the country into global technological leadership, although they are sufficient to allow China to assume leadership in manufacturing.

Effects of renewable energy policies

Fossil-fuel substitution and environmental benefits

By the end of 2010, the cumulative installed capacity of hydropower had reached 216 GW, having doubled since 2005; the cumulated installed capacity of on-grid wind power reached 31 GW; the cumulative installation of solar PV was 0.8 GW; while the annual growth rate of the utilization of solar water heaters has remained strong, at between 10 and 20 percent (Table 10.2). Consequently, the utilization of renewable energy increased to 286 million tce in 2010 from 166 million tce in 2005, with an average annual growth rate of 11.5 percent (NRDC, 2012a).

Out of China's total primary energy consumption of 3.08 billion tce in 2010, renewable energy accounted for a total of 9.29 percent. According to TFYPRED, total energy generation by renewable energy (including large hydro power) should reach 478 million tce by 2015, which will approach the 15 percent target set by the national government for 2020. The utilization of renewable energy will also result in the annual mitigation of 1 billion tons of CO_2, 7 million tons of SO_2, 3 million tons of N_XO, 4 million tons of other smoke emissions, and 2.5 billion m^3 of water conservation (NDRC, 2012a).

Green industries development and jobs creation

Renewable energy development has the potential to encourage technological advances and national manufacturing development. With the growth of renewable energy, China's green power industries have experienced vigorous development.

Wind power manufacturers

In 2011, more than 121 wind-turbine manufacturing facilities, 54 blade facilities, 36 generator facilities, 33 gearbox facilities, 25 bearing facilities, and 43 converter facilities were located in 25 provinces, including foreign-owned enterprises, joint venture enterprises and domestic enterprises. The total capacity of China's wind turbine manufacturers had reached 30 GW in 2011, with nine domestic manufacturers each capable of supplying more than 500 MW annually. In comparison, the number of suppliers with a capacity exceeding 300 MW was 12 in 2010, up from only 1 in 2006 (IEA, 2012). Domestic manufacturers have rapidly increased their market share, and now account for almost 90 percent of annual additional installations

Table 10.2 Renewable energy development in China during the 11th Five-year Plan period

	Application	**2005**	**2010**	**2015 targets**	**Energy generation (million tce/a)***
Power generation	Hydropower	117 GW	216 GW	260 GW	390
	Wind (on grid)	1.26 GW	31 GW	100 GW	
	Solar PV	0.07 GW	0.8 GW	21 GW	
	Biomass	2 GW	5.5 GW	13 GW	
Gas generation	Biogas	8 billion m^3	14 billion m^3	22 billion m^3	17.5
Heat generation	Solar water heaters	80 million m^2	168 million m^2	400 million m^2	60.5
	Geothermal	2 million tce	4.6 million tce	15 million tce	
Fuel generation	Bio-ethanol	1.02 million ton	1.80 million ton	4 million ton	10
	Biodiesel	0.05 million ton	0.5 million ton	1 million ton	
Energy generation (million tce)		166	286	478	

Note: *tce/a means tce per annum.

and more than 70 percent of accumulated installations. In these few years, domestic manufacturers have also entered the international market and, currently, four Chinese enterprises have broken into the world's top-ten manufacturers in terms of global sales. Yet, as new domestic installations supplied only 18 GW and overseas market development was still in its infancy, almost 40 percent of the Chinese production capacity was idle (Cleantech, 2012; Li, 2012).

Solar PV manufacturers

Pulled primarily by European market demand, China's photovoltaic cell-manufacturing industry developed rapidly from 2004 onwards, and China became the world's largest manufacturer of PV cells in 2007. Total production capacity was 10 GW in 2010, accounting for 45 percent of global volume. The top ten companies accounted for 86 percent of total national production. However, heavy dependence on European and U.S. markets also resulted in severe blows to solar PV manufacturers in China. Since March 2012, the United States has imposed an anti-dumping duty on Chinese PV products, ranging from 18.32 to 249.96 percent, and as a countervailing duty of between 14.78 and 15.97 percent (Caijing, 2012). The 11.8 percent anti-dumping duty imposed by the European Union was

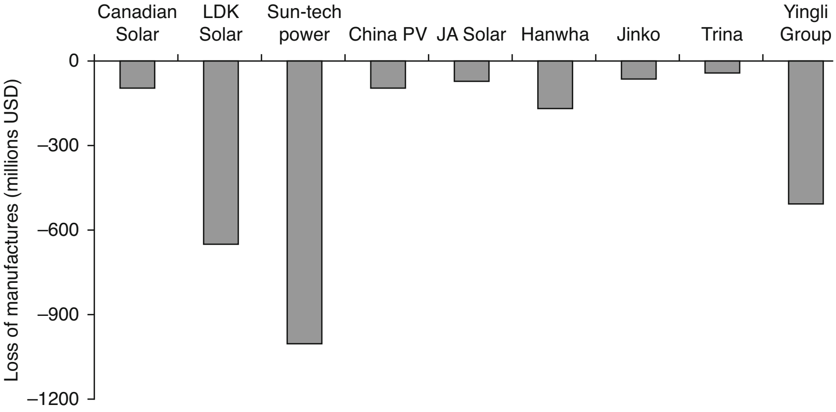


Figure 10.7 Chinese solar PV manufacturers' financial losses (2011)
Source: ifeng.com (2013).

more damaging for China's PV manufacturers, since Europe accounts for 70 percent of the global PV market (ecns.cn, 2013). Since 2011, one-third of Chinese PV manufacturers have been closed down, and, out of a total of 11 Chinese PV manufacturers that have been listed on U.S. stock markets, 9 suffered huge losses. The largest company, Sun-tech Power, suffered a staggering 1 billion USD in losses (ifeng.com, 2013). On March 20, 2013, Sun-tech Power went bankrupt, thereby demonstrating that the Chinese government has now decided to let the market mechanism play a bigger role in the PV industry, and implying less government interference in the future.

Green jobs

China is trying to change the coal-dominated energy structure by incorporating a higher share of renewable energy, so that the energy mix would contribute significantly to environmental protection and to mitigation of greenhouse-gas emissions. According to the World Watch Report, during China's 11th Five-year economic plan period, its solar PV power sector annually generated an average of 2,700 direct jobs and 6,500 indirect jobs (World Watch Institute, 2011). According to China's wind roadmap, its wind-power industry, including the power-generation and turbine-manufacturing sectors, created approximately 40,000 direct green jobs and 51,500 green jobs (Wang et al., 2011).

Given the rapid growth of China's renewable energy industry and potential upward revisions in government projections, the estimates for future green jobs could increase significantly in the coming decade. Nonetheless, both wind-turbine and PV-cell manufacturers in China face excess capacity and industry restructuring, thereby creating major uncertainties for estimates of future capacity and green-job creation in these two industries.

Barriers to renewable energy development

Weak and incomplete incentive and supervision mechanisms

The most burning issues facing renewable energy development in China are technical and economic challenges. Although renewable energy has experienced rapid technological innovation and has increasingly become economically competitive, except for large-scale hydro power and solar water heaters, renewables remain at a stage where technological development is rapid, but costs remain relatively high.

The energy authorities implemented subsidies, tax and R&D policies and various other measures to encourage the development of renewable energy, but there are no policies clarifying the details of the renewable energy development fund yet. Although the government has mentioned the establishment of this fund in the new version of the Renewable Energy Law, related supporting policies have not been worked out. With the rapid growth of renewable energy, investment in R&D, and subsidies increased as well. Nonetheless, financial and managerial instruments are not in place and, consequently, the available financial resources are insufficient for realizing the goals of the renewable energy development strategy.

Lack of policy coordination and consistency

Unlike the traditional (non-renewable) energy system, responsibility for China's renewable energy business is divided among a number of sectors, making it difficult to have a consistent energy policy (Zhang et al., 2009). Although the new renewable energy law regulates the integration of provincial targets and plans with the national strategy, there are still many wind projects that set their capacity scale below 50 MW so as to avoid the complex approval process at the national level. This has at times yielded rather irrational development patterns for China's wind resources and resulted in rapid growth of unused wind-power capacity. For example, part of the electricity generated by wind in Inner Mongolia has to be transferred to the North China grid because of limited local consumption capacity. However, with the construction of the HeBei wind power plants there is no room for the North China grid to accept more electricity from Inner Mongolia, which further undermines the market for Inner Mongolian wind power.

Conflicts between renewable power generators and grid companies

Grid access is crucial for the commercial success of renewables. Electrical system operation and management have focused mainly on large electrical generating sources and large grids, and are therefore not well-suited for integrating renewable but intermittent power systems. The challenge for power-system operation has become increased with the growing scale of renewable energy development. According to a report published by the State Electricity Regulatory Commission (SERC, 2011), a total of 2,800 GWh of wind-generated electricity went unpurchased during the first half of 2010. The reasons for this could include:

- The government only defines the purchasing relationship between power-generation enterprises and grid companies; there is still a lack of regulating methods for implementing the government's mandatory quotas of renewable energy carriage for power-grid companies.
- There are still no transparent and powerful supervision instruments in place. The energy authorities have announced that grid companies are required to purchase all electricity produced by renewable energy facilities (Chen and Zhu, 2012). Yet, until the effective lack of regulation mentioned above is rectified this mandate will remain meaningless. As of now, grid companies do not face any clear punitive measures if they fail to fulfill their mandatory obligations.
- The mismatch between wind power and other power resources in Northeastern China also limits the access of wind power to grid. A high proportion of co-generation facilities are used to supply both electricity and heat in the winter season in Northeast China (72 percent in Jilin Province). These units basically do not have peaking capacity (that is, they have to run at 100 percent of capacity whenever they are turned on) during the winter season; while the middle and small thermal power units with peaking capacity have been gradually shut down since the beginning of the 11th Five-year Plan period. Against the background of a serious shortage in power peaking capacity, grid management entities have been forced to restrict wind power's access to the grid in order to protect electricity network stability and residents' heating supply.

A lack of innovation in R&D and regional policy

Basic research and technology development are the keys for maintaining and improving the competitiveness of the rising renewable energy industries. Both government and industries should pay more attention to basic research and technological innovation. China has just established an industry system through introducing, assimilating and absorbing technologies from abroad. Most of the core technologies are therefore imported. Independent innovation, technology upgrading and talent-grooming are crucial to the industry. Both the state and the industry must increase their R&D contribution to renewable energy so as to improve the technological level.

Furthermore, promotion measures have yet to be adjusted to local conditions in terms of existing regional renewable energy policies. The state still relies on macro-policy instructions that apply nationwide. Because of large differences between different regions of China, the state's macro policies are not equally applicable for each region. Therefore, the government should enhance the regulatory capabilities of provincial authorities and switch from nationwide policies to policies that target different measures to the different regions based on local conditions.

Conclusions

The REL of 2005 marked a new stage for renewable energy development in China. With the encouragement of, and incentives for, renewable energy policies, the utilization of renewable energy reached almost 300 million tce in 2010, and will reach nearly 500 million tce by 2015 according to the latest plan.

The development of renewable energy would not only provide a sustainable energy supply and ensure energy security, but also could bring environmental benefits. According to estimates in the plan, the utilization of renewable energy will also result in the annual mitigation of 1 billion tons of CO_2, 7 million tons of SO_2, 3 million tons of N_XO, 4 million tons of smoke, and 2.5 billion m^3 of water conservation by 2015.

A lack of sufficient incentives has hampered the development of renewable energy industries. The introduction of incentive policies for renewable energy industries has, on the one hand, encouraged the development of renewable energy. On the other hand, under-funding of these incentives has created an almost two-year lag time between project completion and the receipt of subsidies, and this has caused financial problems for small- and medium-size developers and manufacturers.

A lack of coordination and consistency in national and regional policies and among management agencies led to over-expansion and to enterprise restructuring (and shakeout) within both wind and solar power. The growth of domestic wind-turbine and solar-PV industries has certainly increased technology transfers from industrially advanced counties. Nonetheless, in the case of PV manufacturers, heavy dependence on global markets has also resulted in the bankruptcy of numerous suppliers due to sudden shifts in overseas markets and trade frictions. Although the Chinese government adjusted its target for solar-PV installation dramatically upwards in the TFYPRED, it remains to be seen whether this will provide enough of a stimulus to significantly expand the domestic market.

The difficulty of feeding renewable power into the grid is the most important challenge facing China's renewable energy development. The key reason is that the high installation costs have made grid enterprises reluctant to connect wind power to the main grid network, even though they are legally required to do so by the REL and by the SERC executive order. Furthermore, frequently recurring imbalances between wind-power supply and electricity demand also limit the feeding of wind power into grid. The outline of the 12th Five-year Plan for Economic and Social Development proposes the construction of enhanced grid-connection support projects to promote the more effective development and utilization of wind power. With China having now achieved 75 GW of total installed capacity for wind power by the end of 2012, the plan of the national grid to accommodate 100 GW wind power needs to be implemented as soon as possible. Grid construction could certainly alleviate the current difficulties faced by renewable energy plants.

Acknowledgments

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11

From ‘Worn’ to ‘Green’ China Model? Energy in the 12th Five-Year Plan in an Environmental and Climate-Change Perspective

Jørgen Delman and Ole Odgaard

Introduction

Since the reforms started in 1978, the Chinese development model has been exceptionally successful in delivering growth, but it has also depleted China’s resources dramatically and has been based on the use of highly polluting fossil fuels. On a range of critical environmental parameters, China is now the world’s ‘biggest’ or ’worst’ and it contributes considerably to the decline in the health of the globe as well as of China and its people (Liu and Diamond, 2005). Effectively, the growth-oriented model, dubbed the ‘China model’,[1] which has been pursued during the first three decades of reform, has become environmentally untenable. While the model has been hyped as a unique and successful approach to development,[2] it has gradually been realized that it needs to be more sustainable (Pan, 2011). Following years of criticisms of China’s environmental destruction from within and outside the country,[3] new development concepts such as: ‘science-based development’, ‘sustainable development’, ‘green transformation’, ‘low-carbon development’, ‘circular economy’, and ‘green development’ are now being propagated by the Chinese leadership to move China away from the seriously ‘worn’ China model towards a more sustainable ‘green’ China model.

These principles were enshrined in the 12th Five-year Plan (12th FYP) for the period 2011–15, which was adopted by the Chinese National People’s Congress in March 2011. The plan strengthens the focus of the previous FYP with the new development paradigm with more ‘green’ (*lüse* 绿色) growth based on a ‘low-carbon’ (*ditan*低碳发展) philosophy. Energy policies are obviously central to the success of these ambitions, and the ‘green’ energy goals put forward are predicated on: (a) the introduction during the previous FYP period of targets for development of renewable energy; (b) a new national renewable energy law with comprehensive support schemes from 2005 onwards; and (c) a higher priority for energy efficiency (12th FYP, 2011). Effectively, the 11th and 12th FYP have slowly but surely linked energy, environment, and climate change into the new green development concept (Pan, 2011), and the 12th FYP took a new step in moving towards the paradigmatic green turn in socio-economic development with a better balance between growth and environmental sustainability.

Building on past achievements with addressing political, technological, and economic development imperatives in focused sector programs, the 12th FYP lists ambitious goals for addressing the need to improve the environment, to reduce energy consumption in relative terms, and to make energy cleaner. For the first time, a target for energy-related CO_2 emissions (GHG) was also included. The strong focus until now on increasing the share of renewable energy in total energy consumption is maintained,[4] and the efforts to reduce the environmental impact and costs of China's rapid development will be intensified. The concrete energy, environment, and climate-related targets account for 33.3 percent of the quantitative targets in the plan as compared to 27.2 percent in the 11th FYP (Economy, 2011; Hu and Liang, 2011). Chinese Academy of Social Sciences professor Pan Jiahua, one of China's leading and most influential environmental and climate change experts, echoed the Chinese leadership's concerns in a blog post in 2011: 'Green development is a historical necessity'.[5]

The green approach must be viewed in the context of the evident preference for continued economic growth. The annual GDP growth target for the plan period is set at 7 percent, 0.5 percentage point under the target in the 11th FYP (2006–10). But the real growth during the 11th FYP period was 10.2 percent annually,[6] and only two of China's provinces have announced growth goals at around 7 percent for the 12th FYP period, with several provinces having set their targets as high as around 13 percent (APCO, 2011). The suggestion is therefore that the Chinese government may well face considerable difficulties in enforcing its strategic goal to reduce the speed of growth in some provinces, and if the high growth rates are sustained, more energy will be needed, which will have a detrimental impact on the environment, since most of the energy will come from coal. Therefore, the challenge is whether green growth, de facto, can add more sustainability to the previous exclusive focus on economic growth.

Furthermore, most of the targets in the 12th FYP are indicative and not binding. The plan is no longer called a *jihua* (计划), a form of planning that was, at least in principle, supposed to work on the basis of 'hard', achievable, and controllable targets. The practice since 2005 has been to call it a *guihua* (规划), which implies a more indicative approach and connotes a more managerial and supervisory role for the Communist Party and the Government (Sigley, 2006). Finally, the unknown factor is whether the Chinese 'party-state' government – with its traditional focus on promoting non-stop high growth relying on local initiative and associated incentives – is capable of implementing its ambitious green goals at the grassroots level.

Therefore, in this chapter we ask whether the reinforced linkages between energy, environment, and climate policies in the 12th FYP make sense in relation to reconfiguring the China model, and what the possible impacts and prospects are of this approach. First, we examine China's environmental degradation, the energy situation, and the climate change challenge. We will then discuss the efforts to rethink the 'China model'. After that, we turn to an examination of the nature and implications of the energy related initiatives outlined in the new 12th FYP. Finally, we will discuss the prospects and challenges for the possible success of the 'green' China model. We conclude that although China's 12th Five year Plan is ambitious with regard to 'green' targets, developments on the ground rooted in the specific nature of China's political economy may easily undermine the ambitions, not least if growth is not held at bay as planned and local interests are not given incentives to turn 'green'.

The 'sad' condition of the environment

It is an established fact that growth is eating up China's resources at a pace faster than they can be regenerated, recovered, or substituted by alternatives. China is the second-largest economy in the world, and it is the world's biggest polluter and the largest contributor to global climate change in absolute terms (IEA, 2010). The influence of environmental factors and their consequence for economic development and public health have long attracted serious attention. In an interview in 2005, the Chinese deputy environment minister, Pan Yue, expressed his concern about the Chinese growth model and discussed whether it had become its own worst enemy: 'I am worried. We are using too many raw materials to sustain this growth. ... This miracle will end soon because the environment can no longer keep pace (*Der Spiegel*, 2005)'.

Environmental degradation is visible everywhere. China's lands experience extensive overgrazing, and huge tracts of agricultural land have been transformed into desert during the last few decades; 38 percent of China's area is affected by serious erosion, among the worst in the world. China has the highest ratio of actual-to-potential desertification of any country in the world (World Bank, 2001). The area covered by forest is comparatively small (18 percent), although now increasing; most of the virgin forest was cut down long ago. Wetlands and watersheds are being depleted at an alarming rate due to intensification of agriculture and China's rapid urbanization (Liu and Diamond, 2005). Half of China's population now live in urban areas, as compared to 19 percent in 1980, and China may have as many as one billion urban residents in 2030 (McKinsey, 2009).

With regard to water, the coastline waters around China have been practically emptied of biological resources, and in many places land-based water resources are exhausted. 43 percent of the water in the seven biggest rivers is so polluted that the water is unsuitable for human use. A fourth of the population cannot access clean drinking water (*Economist*, 2010). About 70 percent of all surface water is polluted to a serious degree (Economy, 2007).

Air quality is becoming exceedingly worse. The use of vehicles is growing rapidly. As of August 2009, China had 180 million vehicles, and the number is estimated to increase by more than a million each month.[7] China's air is also strongly affected by the intensive use of coal in its energy system; 20 of the world's 30 most polluted cities are located on Chinese soil, and up to 90 percent of the sulphur dioxide pollution and 50 percent of particulate pollution are due to the use of coal. One third of the population breathes heavily polluted air. Acid rain falls on one third of the cultivated area and on half of the Chinese cities (Worldwatch Institute, 2006). Beijing spent US$10 billion in an attempt to reduce air pollution in conjunction with the Olympic Games in 2008. It was a temporary success as the capital experienced a 30 percent reduction in air pollution, but 60 percent of the gain has since been lost (Davis, 2009). At the end of 2012 and the beginning of 2013, a large tract of China's territory was covered by the worst smog ever.[8] In Beijing alone, 70–80 percent of all incidents of cancer causing death are due to environmental impact, and lung cancer has become the primary cause of (*Der Spiegel*, 2005).

Depending on the analytical approach, the environmental impact of China's rapid growth may cost the country somewhere between 8 and 15 percent of its GDP annually (*Der Spiegel*, 2005; World Bank et al., 2007). In late 2012, the Academy of Social Sciences concluded that average real growth rates were not 10 percent during the reform period, but rather 5 percent, if the environmental cost were factored in (Shekeyuan, 2012). With regard to environmental sustainability, China is 116 on a list of 132 countries (Environmental Performance Index, 2012). China's challenges are enormous and are aggravated by the fact that only one tenth of its total land area is suitable for human habitation and agricultural use. This is where the environmental degradation hits the hardest, and it will make it even more difficult to absorb the part of the population that will migrate from the areas threatened by environmental degradation. China may have as many 150 million environmental migrants without a permanent residence within the next few years (*Der Spiegel*, 2005).

China's people do not sit on their hands while their natural resources are being depleted or deteriorated and their health is put at stake. In 2006 alone, authorities had to handle 580,000 complaints relating to environmental issues from ordinary citizens (Cary, 2011).[9] But it may be difficult to get support from strong local public and business interests. In July 2007, the Chinese minister of the environment noted: 'Some businesses don't rest deep in the night, when they have no scruples about dumping pollution in rivers'. He referred to a survey of 529 enterprises situated close to China's important rivers, which showed that 44 percent of them had not abided by environmental regulations, while 75 percent of their waste-water treatment facilities were either not meeting official standards or did not function at all. The minister of the environment compared the water of the rivers to 'sticky glue' (Watts, 2007).

The energy situation

The China model has created an enormous appetite for energy, especially coal. Energy consumption almost doubled through the 1980s and the 1990s, the first two decades of the reforms, but after 2000 the consumption of energy was doubled in only eight years (Table 11.1). China's industrial development has been the main driver of this development, and China's use of coal is the most important reason for the serious air pollution, for the occurrence of acid rains, for extensive soil and water pollution and, finally, for China becoming the country in the world with the highest level of CO_2 as well as aggregate greenhouse gas (GHG) emissions.

China has had plenty of coal, which has accounted for about 70 percent of total energy consumption since the reforms started at the end of the 1970s (cf., Table 11.1). But the use of coal is very ineffective, as in 2010 the country used 46 percent of the coal consumed in the world to produce only 8 percent of the world's GDP (IEA, 2012; World Bank: World Development Indicators Database).

Table 11.1 China's energy consumption and types of energy, 1980–2010

		Gross Energy consumption (%)			
Year	**Energy consumption (mill. t coal equivalents)**	**Coal**	**Oil**	**Natural gas**	**Non-fossil energy: Renewable and nuclear energy**
1980	603	72.2	20.7	3.1	4.0
1985	767	75.8	17.1	2.2	4.9
1990	987	76.2	16.6	2.1	5.1
1995	1,312	74.6	17.5	1.8	6.1
2000	1,455	69.2	22.2	2.2	6.4
2005	2,360	70.8	19.8	2.6	6.8
2009	3,066	70.4	17.9	3.9	7.8
2010	3,249	68.0	19.0	4.4	8.6

Source: China Statistical Yearbook (2011).

Energy saving is one way of reducing the use of harmful fossil fuels. The 11th FYP brought forward a series of policies to address this issue. The 'Top-1000 Energy Consuming Enterprises Programme' has significantly lowered the energy consumption by enterprises in nine industrial sectors that consume 180,000 tons of coal equivalent (tce) or higher annually per enterprise. New building energy standards were also elaborated to ensure higher energy efficiency. This was an important measure, as China accounts for about half of all new construction worldwide. Small, inefficient factories and plants were to be closed. Electrical appliance standards and energy-efficient labels were promoted to save energy, as were a number of other policies to promote energy efficiency (Price et al., 2011; Mastny, 2010).

Expansion of the use of renewable energy is another way of bringing down the use of fossil fuels. The previous FYP had as a target that renewables should constitute 10 percent of energy consumption in 2010, and the government later decided that the share of renewables should be 15 percent by 2020 (NDRC, 2007). The target was not achieved, and the first indication of this was that President Hu Jintao launched a replacement target in 2009 called 'non-fossil' energy instead of 'renewable energy' to be able to include nuclear power in the target (Hu, 2009; Ma, 2011). In spite of this, China only reached a level of 8.6 percent of non-fossil energy in 2010 instead of the originally stipulated 10 percent target for renewables. As China has expanded nuclear power considerably over the last few years, it is clear that in real terms the share of renewables in total energy consumption has been stagnant (cf., Table 11.1).

However, the under-fulfillment of the renewable energy target does not signal failure for this sector. On the contrary, due to the constant high economic growth, the coal-based energy consumption has grown with such a momentum that even a stagnant market share for renewables actually represents a sharp increase in commissioned power-generation equipment. As we have seen above, the annual GDP growth rate was planned at 7.5 percent in the 11th FYP, but the de facto rate was 10.2 percent. Therefore, hydro, nuclear, and the new renewable energy sectors all grew faster than anywhere else in the world; but coal and oil did as well.

Indeed, the development of non-fossil power capacity has been impressive. China had 1 GW of installed wind power by 2005, which was upped to 42 GW in 2010, the highest in the world. By 2015, China is expected to have commissioned 123 GW and possibly much more. Nuclear power increased from 7 GW in 2005 to 33 GW by 2010 and is expected to reach 70 GW by 2015. Hydro power, by far the largest source of renewable energy, expanded from 117 GW in 2005 to 213 GW in 2010, and is expected to hit another record level of 285 GW by 2015 (IEA, 2012).

Yet, even if China persists with energy efficiency improvements at the current rate, so as to transform the economy in a greener direction, energy consumption will still double from 2005 to 2020 (ERI, 2009). This means

Table 11.2 China's energy consumption and climate-change load compared to other countries and regions, 2010

	1	2	3	4	5	6	7	8	9	10	11	12
Country	**Population (mill.)**	**GDP (bill. US$)**	**GDP (in PPP bill. US$)**	**Energy consump-tion (TPES, Mtoe)**	**Consump-tion of electricity (TWh)**	**CO2 emission (mill. tons)**	**Energy consumption per cap. (toe/ cap.)**	**Energy consumpt-ion per GDP-unit (toe/ 1000 US$)**	**CO_2 per TPES unit (tCO2 / toe)**	**CO_2 per cap. (tCO_2 / cap.)**	**CO_2 per GDP unit (kg CO_2 / US$)**	**CO_2 per GDP unit (PPP) (kg CO_2 / US$)**
World	6,825	50,942	68,431	12,717	19,738	30,326	1.86	0.25	2.38	4.44	0.60	0.44
China	1,345	4,053	9,417	2,431	3,980	7,311	1.81	0.60	3.01	5.43	1.80	0.78
India	1,171	1,247	3,763	693	755	1,626	0.59	0.56	2.35	1.39	1.30	0.43
OECD	1,232	37,494	37,113	5,406	10,246	12,440	4.39	0.14	2.30	10.10	0.33	0.34
Denmark	5.55	256	179	19	35	47	3.47	0.08	2.44	8.48	0.18	0.26
Japan	127	5,579	4,895	497	1,070	1,143	3.90	0.11	2.30	8.97	0.25	0.29

Notes: 'CO_2 emissions' based on energy related emissions
'billion US$': all US$ in table in year 2005 prices
'Mtoe' = mill. tons oil equivalents
'toe' = tons of oil equivalents
'PPP' = Purchasing Power Parity
'TPES' = Total Primary Energy Supply
'TWh' = Terawatt Hours
Source: IEA (2011)

that China must increase its imports of oil (net importer since 1993), gas (net importer since 2007), and even coal (net importer since 2009). Importation of coal is necessary, since the railways are unable to transport coal fast enough from the coal-rich mines in Northwest China to the economic growth centers in South and East China.

Furthermore, China's own energy resources now stand at a very low level. The Chinese per capita average of both coal and hydropower resources is 50 percent of global average per capita resources, while the per capita average of both oil and natural gas resources is only about one fifteenth of the global average (State Council, 2007). Therefore, energy security is also a strong factor behind the new focus of the Chinese government on green growth.

The climate challenge

The interconnection between economic growth, energy, environment, and climate is substantial, and Table 11.2 puts China in a global perspective by comparing it with the average of countries belonging to the Organization for Economic Cooperation and Development (OECD), India, and Denmark. Only half-way through its industrialization China is already the world's largest consumer of energy (column 4) and at the same time the biggest emitter of energy-based CO_2 (column 6). In contrast, China still uses two and a half times less energy per capita compared to the OECD countries (column 7), but the lower level of energy consumption is partly leveraged by poorer energy and carbon efficiency (columns 9-12). Therefore, China still has potential for reaping significant energy savings (column 8), as the country uses four times as much energy per GDP unit as compared to the OECD countries. China also has a great potential to reduce CO_2 emissions per US$ GDP unit (China: 1.8 kg per US$ GDP; OECD: 0.3 per US$ GDP; see column 11) and this is exactly the reason why China has formulated its GHG emissions-reduction as a target that aims to reduce its CO_2 emissions by 40–45 percent per GDP unit in 2020 as compared to 2005 (IEA, 2012).[10] It should also be noted that the OECD emits almost twice as much CO_2 per capita as China (column 10).

The dramatic growth in China's energy consumption has resulted in China accounting for the largest part of the incremental global demand for coal and oil and therefore to CO_2 emissions as well (see Figure 11.1). This will continue in the future despite the new Chinese goals for more non-fossil energy and CO_2-intensity improvement. If all of China's green goals are fulfilled, China's use of coal in absolute terms will still increase. While China's coal consumption accounted for an 86 percent increase in aggregate global net growth during the period 1990–2010, this increase will still make up half of the global net growth during the next decades. Interestingly, China's net growth in oil demand and nuclear power will make up more

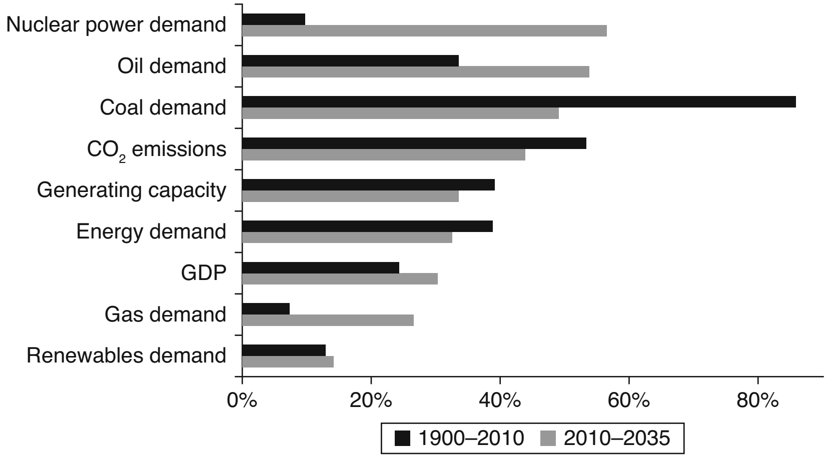

Figure 11.1 China's share of incremental energy demand and energy-related CO_2 emissions, 1990–2010 and 2010–35

Sources: IEA (2011) and IEA (2010).

Table 11.3 Selected targets in the Five-year Plans and accompanying Long- and Medium-term Plans

	11th FYP Target (2010)	**11th FYP Actual result (2010)**	**12th FYP Target (2015)**	**Goal 2020**
Share of non-fossil energy in primary energy (hydro, new renewables, nuclear)	10% (for RE only)	8.6%	11.4%	15%
Energy consumption per GDP unit (=energy intensity)	–20%	–19.1%	–16%	–
CO_2 emissions per GDP unit (=carbon intensity)	–	–	–17%	–40% to –45%
Forest coverage	20%	20.4%	21.7%	23%
Green tech's contribution to GDP (incl. IT and biotechnology)	–	5%	8%	15%

Note: 'Energy consumption' denotes gross energy consumption. The share of non-fossil fuels in electricity consumption applies only to large utilities with a capacity above 5000 MW – and this target is indicative, not binding.

Sources: NDRC (2007), State Council (2011), APCO (2011), and Hu (2009).

than half of the global total till year 2035. This happens at the same time as China's share of net growth in renewable energy ranges between 13 and 14 percent.[11]

China's growing energy demand will especially take place from 2000 to 2020 and to illustrate the magnitude of this development, China's incremental demand for coal in 2009 and 2010 alone equals the total EU use of coal (Cronshaw, 2011).

Worn China model

China's development during the reform period has been captured in the widely acknowledged concept, the 'China model', which explains the drivers of the country's growth miracle. It is an empirical explanation comprising the following elements according to authoritative Chinese analysts subscribing to it: pragmatic and gradualist economic reforms, a dynamic hybrid economy called the 'socialist market economy', integration with the global economy, focus on the needs of the people, an authoritarian state as a strong actor in the economy, political stability, and repudiation of Western universal values (Pan, 2007; *People's Daily Online*, 2009; Zhang, 2011).

In the original conception, the China model was part of the so-called 'Beijing Consensus' and was seen as an alternative to the neo-liberal 'Washington Consensus' (Ramo, 2004).[12] Lu (World Bank) argues that the China model reflects a distinct national practice. Due to its historical experience with a planned economy, the Chinese leadership has developed a solid tool box that opens up for continuous strategic interventions in the economy. Furthermore, the one-party-state plays a central role in relation to the business sector due to its control of the financial sector and a range of other large state-owned enterprises in strategic sectors. Based on increasing central tax revenues resulting from tax reform in the 1990s and revenues from the state-owned enterprises as well as land sales, the government has developed substantial financial power that it can employ actively in the economy. Finally, the Chinese approach to planning has a much longer time horizon than is the case in most democratic countries, and even if the political process is driven from the top, it is sufficiently flexible and adaptable to leave room for local experiments (Lu, 2011).

There are also less-hyped views about the Chinese miracle. Naughton (2010) finds that the China model is a simple and pragmatic industrialization policy that has succeeded because the Chinese government has combined focused state interventionism with an authoritarian state system, a regime which has been continuously provided with new goals and incentives that both require and facilitate rapid growth. The market and the state have avoided collapse because they have managed to adapt to each other; not least, the market has been able to adapt to the interests and needs of the authoritarian state. Yang argues that the China model is just a *status quo* model that cements the control over the economy by the powers-that-be in order to primarily serve their own interests (Yang, 2011).

In the final analysis, the China model is a pragmatic explanatory framework attempting to capture the drivers underlying China's development path during the reform period since 1978, as well as the dynamic interplay between central and local actors. It centers on economic and technological drivers as well as the political incentives driving this development. However, despite his praise, Ramo (2004) also found that the China model leads to pollution, social instability, corruption, lack of trust in the government, and unemployment.

Therefore, when China's environmental problems have become so serious as to threaten this well-established development paradigm, it must warrant a critical re-assessment of whether or not the China model is suited for China anymore. This is what the Chinese leadership appears to have been doing, especially over the last decade.

12th Five-year Plan: shift of paradigm?

The reflections of the leadership have been translated into more progressive green policies in the 12th FYP. Table 11.3 shows how the relevant key targets for energy and climate change have been developed from the 11th to the 12th FYP and the actual results at the end of the 11th FYP. According to the 12th FYP, the share of non-fossil energy in the economy is to grow much faster than up until now, from 6.4 percent in 2000 to 8.6 percent in 2010 and to 11.4 percent in 2015.

Overall, energy consumption is to be reduced by 16 percent per GDP unit in 2015 compared to 2010 (Table 11.3). This is lower, though, than the targeted 20 percent in the previous FYP, a goal which was almost met. Up until now, China has effectively harvested a lot of the low-hanging fruit with regard to improved energy efficiency, and it will be more difficult to obtain large reductions from new energy-efficiency measures down the line. Furthermore, the forest area is to increase by 1.3 percent to 21.7 percent (Table 11.3), and the overall target for CO_2 emissions reductions is set at 40–45 percent per GDP unit in 2020 compared to 2008. Finally, the Five-year Plan fixes the intermediate CO_2 emissions reduction target per GDP unit at 17 percent for 2015 (Table 11.3).

At the end of 2010, China was the world's largest producer of wind turbines, solar PV cells, solar thermal panels, power plants based on biomass, nuclear power plants, and hydropower plants (The Climate Group, 2009). China accounted for almost 50 percent of all manufacturing of solar modules and wind turbines in the world. But with only 1 GW of solar energy installed, it is also clear that China mainly produces for export. However, the European trade sanction against Chinese solar PV cells has compelled China to install a great portion of its own solar equipment from 2013 and the rest of the present FYP. China installed 17 GW of wind energy in 2010, which is a big stride in its goal to reach 150 GW of wind by 2020. China accounted for 47 percent of global wind energy investments in 2010 (Pew, 2011). China also leads the world in the installation of solar thermal systems.

However, due to the massive growth in installed capacity of all available energy technologies, including fossil-fuel based energy technologies, the incremental share of renewable technologies in China is less impressive. Renewables accounted for 30 percent of China's total installed power capacity in 2010 compared to approximately 50 percent worldwide that year (REN21, 2011).

While there are indications that China wants to become more green than worn, the picture on the ground is more complicated than that. During the upcoming decades, China will increase its consumption of energy so much (cf., Figure 1) that the green wave cannot make up for the ever-increasing use of coal for power generation. In the 12th FYP, it is expected that China will increase its number of coal-fired power plants by approximately 45 percent, that is, an additional capacity larger than the aggregate capacity of all coal-fired power plants in the EU. The addition of so many new coal-fired power plants in China implies that by 2035 China's incremental capacity will be bigger than the aggregate capacity of all existing coal-fired power plants in the United States, the EU, and Japan combined. Even if China employs the most energy-efficient energy technologies, the use of coal will increase significantly (Odgaard, 2009). The challenge posed to the global climate by these developments defeats any challenge posed by any other contemporary player and demonstrates that China will need concerted action at all levels – international, national, and sub-national – to attain its targets.

Transformation in process set in motion – but?

Effectively, Chinas' leadership has argued for the necessity of handling the environmental challenges for a long time. 'Sustainable development' became a key development concept already in 1993 in connection with the publication of China's 'Agenda 21'. This has been reiterated many times since, most recently in March 2011 when the 12th FYP was passed and in late August 2011 when China's State Council published its subsequent guidelines for the implementation of energy efficiency and climate-change interventions under the 12th FYP (State Council, 2011). China's increasingly deeper engagement with the collaborative international frameworks regarding environment, energy, and climate change has also contributed to heightening the national focus on the environmental and climate-change challenges (Ibitz, 2011; Delman, 2011; Harris and Ugadawa, 2004).

Yet, if China shows both will and determination, the Chinese climate targets are not as ambitious as they may sound. According to the Chinese Energy Administration, China's GDP is expected to grow 3.5 times during the period 2005–20 (ERI, 2009). This will lead to the drastic increase in demand for energy discussed above (cf., Figure 1). If China merely continues to acquire and employ the most energy-efficient technologies available, the use of such equipment will by itself contribute significantly to the attainment of the emissions-reduction target. According to the Chinese Energy Administration, China could actually improve its carbon intensity by 44 percent just by following existing policies (ERI, 2009).[13] The United Nations Development Program's (UNDP) assessment is that improving carbon intensity by 40 percent is achievable without any additional expenses (UNDP, 2010). Therefore, the Chinese Energy Administration seems to have originally recommended a more ambitious climate target with a reduction in carbon intensity of 50 percent, which was cut to a maximum of 45 percent by the government in order to maintain a safety margin.[14] Subsequently, the government opted for the less ambitious 40–45 percent reduction announced just before the COP 15 in Copenhagen in December 2009 (Delman, 2011).

An analysis made by Climate Action Tracker shows that China is well on its way to meet – or even surpass – its target of a 40–45 percent improved carbon intensity by 2020. Even if China experiences faster than expected economic growth and production of goods and thus consumption of energy rises substantially, the newly installed equipment to cater to these needs will be of the most modern and energy-efficient kind and this will automatically improve the carbon efficiency more than expected under a moderate growth scenario. In 2020 emissions are in fact likely to be higher than previously estimated – by 1 Gt of CO_2e per year. China's aggregate GHG emissions totalled 7.5 Gt CO_2e in 2005 (Climate Action Tracker, 2011b). China will emit more CO_2 in 2035 than the aggregate emissions of the United States, Canada, the EU, and Japan taken together, unless it decides on more serious mitigation measures than those already announced (IEA, 2010).

China will, however, demand considerable technology transfer and financing to enter into deliberations on a more ambitious target. The complicated international negotiations, especially the negotiations between China and the United States, explain the inability to achieve a new and more ambitious internationally binding climate-change agreement (Delman, 2011; Odgaard, 2010).

As for now, it appears that a new climate-change agreement is not easily attained and that it will be impossible to push China's green development further than already stipulated in the 12th FYP; 86 countries, representing about 80 percent of global emissions, have appended targets (including 42 Annex 1 countries) and/or mitigation actions (44 non-Annex 1 countries) to the 2009 Copenhagen Accord (UNEP, 2011). Some countries have endorsed their targets without linking them to a national strategy for developing climate-friendly technologies. Other countries have taken concerted national actions to link their CO_2 targets with the development of new green high-tech sectors. The latest scenarios suggest that the action taken will not suffice to ensure the attainment of the UN's 2° C target. In order to reduce the rise of the average global temperature to maximum 2° C above the pre-industrial level, global emissions should peak before 2020 at emissions levels of around 44 Gt CO_2e. With the pledges taken into consideration, the actual emissions are expected to be 6–11 Gt CO_2e above this crucial level (UNEP, 2011). As discussed above, China plays a critical role in this respect and its international efforts are linked to its national actions. At the same time, it must be noted that the planned green policies also relate to the need to maintain energy security and to conquer a substantial part of the global market for green technology.

Is it possible to re-engineer the worn China model?

The Chinese leadership is clearly attempting to reconfigure the China model by launching a new green development paradigm as reflected in the 11th and 12th FYPs. The unknown factor is the ability of the party-state to implement, at the local level, the various policies analyzed above. China's so-called 'de facto' federalism (Zheng, 2006), which entails that power is increasingly decentralized and concentrated at the local level, may well prove to be a critical barrier hindering the transition from a worn to a green China model. In this context, the ability to bring down the share of coal in energy production is particularly critical, as it will conflict with interests in the local coal-producing areas, which produce about 50 percent of China's coal (Peng, 2010).

Furthermore, the local environmental authorities often find it difficult to enforce national policies and regulations, if they have any interest in doing so at all, since they are under the influence of strong and independent-minded local governments authorities and not the central government. When the central government issues new restrictions targeting local industry, the local environmental authorities are often punished at their own level if they toe the central party line, for example by suffering reductions in their salaries or their operational budgets.

If a local authority is successful in taking an unresolved environmental case to court, there will be more difficulties. The courts are highly dependent on the local party-state officials. Many environmental cases are so serious that they would warrant considerable fines or other types of legal sanction but, as an example, water regulations do not bind local water authorities to submit relevant data and documentation in support of legal process, which limits the effectiveness of the courts (Congressional, 2007).

If an enterprise is eventually sentenced to a fine and/or to clean up its act, it is not uncommon that the local tax bureau offers a reduction in environmental fees, often the exact same amount as the fine meted out by the court. There are numerous examples that local governments help local enterprises in this way to safeguard local employment and their own tax revenues (*Economist*, 2004). A broad study of environmental legal proceedings in China has shown that half of the charges brought against enterprises were turned down by local authorities (including the local party organization), based on the argument that the outcome of such cases could threaten local social stability, something which is a prime concern for the party-state (Wang, 2010).

However, some necessary reforms seem to be on the way. In recent years, three provinces have established specialized environmental courts that can prosecute environmental trespassers across administrative boundaries. If the experiences of these three provinces turn out to be positive, the plan is to establish such courts in the rest of the country (Congressional, 2009; Lubman, 2010). Effectively, the ability of environmental authorities to monitor the environment and to sanction trespassers will be of considerable importance for the attainment of future climate-change and energy targets.

While facing the challenges of the local political economy, the most important question at this stage is whether or not the central government will be able to replace bureaucratic decrees, ineffective sanctions, and planning targets with more effective tools of implementation. The move from the fixed Five-year Plans of the past to the current indicative Five-year Plan calls for the party-state to create new institutions and mechanisms to monitor and even control local development. It is important that not only the local authorities but also non-state actors perceive of their own interest as one of saving on their use of properly priced scarce resources in order to attain national targets. The 12th FYP and the subsequent implementation guidelines outline the first steps to introduce a carbon tax on fossil resources, resource taxes, and a carbon credit-trading scheme. Together with emerging and often quite active green NGOs, these new instruments are meant to put the local interests in China under pressure, not least those of the local governments and the strong business actors. However, despite the positive developments observed, there is still need for solid evidence that the efforts will be sustainable and not be compromised by new environmental degradation, as has been the case with Beijing's air quality following the improvements ahead of the Olympic Games in 2008.

Conclusions

China's rapid economic development during the reform period since 1978 has been powered by fossil fuels and has incurred huge environmental costs. In recent years, the Chinese leadership has embarked on a redesign of its traditional reformist approach to economic and social development, the so-called 'China model'. Being planned is a green turn aimed at embracing environmental change, climate change and clean and green energy policies while also addressing the need for continued stable economic growth and energy security. While these agendas may seem incompatible, it has been acknowledged that they must be combined to ensure that China can move from an environmentally destructive to a more sustainable China model. However, this shift is a tall order and may be difficult to engineer simply by adopting the traditional top-down approach of the Chinese communist leadership. There is a need to overcome the constraints of China's particular political economy by linking the handling of energy, environmental change, and climate change issues across traditionally incompatible local administrative and economic sectors to the performance of local governments. If successful, the policies that we have examined in this chapter will be the most decisive move for the improvement of China's environment for decades, as it will provide citizens, local enterprises, and governments with real incentives to save on coal and other pollutants in the effort to shift away from the worn to a greener China model. There are positive indications, but it is far too early to judge whether these policies will effectively lead China towards a more sustainable path of development. The smog that hit China at the end of 2012 is a strong warning sign that the green transformation is indeed a 'historical necessity' (Pan, 2011).

Notes

1. A term coined by Ramo (2004) in conjunction with his explication of the so-called 'Beijing Consensus'. Called '*Zhongguo moshi* 中国模式' in Chinese. Ramo also talked about the 'Beijing model'.
2. For example Li et al. (2009) who – rather uncritically – conclude, with regard to the model's viability: 'The best evidence is China's strategic switch to a strategy of building a harmonious society domestically and a harmonious world internationally (p. 308)'.
3. A few examples: (1) from within China: The iconic work of veteran Chinese environmental journalist Dai Qing on the Three Gorges Dam (see her biography on Wikipedia: http://journal.probeinternational.org/three-gorges-probe/dai-qing/dai-qings-biography/; http://en.wikipedia.org/wiki/Dai_Qing; (2) from outside China: Smil (1997), Economy (2010), and Shapiro (2012).
4. Selected targets in Table 11.3.
5. '绿色发展是历史的必然' (Pan, 2011).
6. From National Bureau of Statistics, cited in Chinability: http://www.chinability.com/GDP.htm. Fixed prices in Yuan. If the GDP is measured in fixed US$, the average annual growth will amount to 11.2 percent, according to the World Bank (www.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG).
7. China Accelerates 'Auto and Home Appliances to Countryside' Program, *People's Daily Online*, December 24, 2009.
8. Widely reported in global and local media.
9. The phenomenon seems to be escalating. Liu Jianqiang discusses some of the causes in: 'China's new "middle class" environmental protests.' *China Dialogue*, January 2, 2013. http://www.chinadialogue.net/article/show/single/en/5561-China-s-new-middle-class-environmental-protests. Accessed February 5, 2013.
10. See also Delman (2011).

11. Traditional biomass for cooking and heating is included in the category of renewable energy. Thus the development of modern or commercial biomass, and thereby modern renewable energy, is more extensive than suggested by the figure.
12. 'Washington Consensus' coined by Williamson (1989).
13. See also Climate Action Tracker (2011a).
14. Odgaard, personal information.

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12

Enabling China's Low-Carbon Transition: The 12th Five-Year Plan and the Future Climate Regime

Jiangwen Guo, Eric Zusman and Espen Moe

Introduction

In 2009, the 15th Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen solidified China's place as a pivotal player in climate-change negotiations. But with growing recognition of China's new status came divergent views of its motivations. For some, China was trying to capture the reputational benefits from appearing on a global stage with other major powers, while refusing to cede ground on controversial elements of a future climate regime (Broder and Kanter, 2009; Hood, 2009; Levi, 2009). This chapter argues that playing global politics was not the only motivation for China to engage in climate negotiations. Rather, we maintain that China became more actively engaged in international climate politics for reasons related to domestic energy policies.

Specifically, this chapter contends that the improvements China registered in energy efficiency during its 11th Five-year Plan owe much to command–control regulations, reporting protocols, and performance incentives with origins predating China's current market-reform era. In the 12th Five-year Plan, China will begin piloting programs (such as 'Low-carbon Provinces and Cities') and deploying market-based instruments (such as emissions-trading programs and possibly a carbon tax) requiring reporting protocols and performance incentives aligned with the current market-reform era. Thus, the developments highlighted in this chapter could signal the beginning of a potentially major change to the political economy of energy in China. In enabling this low-carbon transition, future climate agreements could help standardize monitoring protocols and introduce the kind of market-driven performance incentives needed to drive forward China's low-carbon transition.

The chapter is divided into three sections. The first section outlines energy reforms in China's 11th Five-year Plan. The second section outlines the changing scope and orientation of those reforms in the 12th Five-year Plan. The final section concludes with recommendations for aligning policy and institutional reforms at the national and global levels. The chapter draws upon a set of 11 semi-structured interviews conducted with researchers, professors, and policymakers in China during the fall of 2010. The interviewees' general profiles are listed in the appended interview file based upon an agreement for anonymity.

The 11th Five-year Plan (2006–10)

Over the past decade, China has introduced a series of high-profile climate and energy-policy reforms broadly consistent with leadership support for a 'scientific development perspective' (科学发展观). Notable among these reforms are the submission in 2004 of China's Initial National Communication (INC) to the UNFCCC (State Development Planning Commission, 2004); China's National Climate Change Program (CNCCP) in 2007 (National Development and Reform Commission, 2007); and the *White Paper on Climate Change* in 2008 (State Council, 2008). Many of China's national-level mitigation actions are listed in the INC, the CNCCP, and the *White Paper*. Yet, arguably, the most important milestones are included in its five-year plans (see Fei et al., 2009).

China's five-year plans are comprehensive planning documents that once provided a detailed blueprint for virtually every aspect of the economy. Yet, even as more commodities move from the plan to the market, the documents continue to offer a revealing window into China's policy priorities. In the 11th Five-year Plan, one of the most important of these priorities was recapturing nearly two decades of gains in energy efficiency (Andrews-Speed, 2009; Zhao et al., 2010). By 2003, increased demand for energy-intensive exports and expanded production in heavy industries began to erode these efficiency gains (Zhao et al., 2009; Zhang, 2010). The lost momentum was worrying to a Chinese leadership that saw its national security as riding on reliable supplies of affordable energy.

These concerns were articulated in the 11th Five-year Plan with calls for 'push[ing] forward the optimization and upgrading industrial structure' and 'constructing a resource efficient and environmental friendly society'. In more concrete terms, the 11th Five-year Plan advanced a goal to increase non-fossil fuel use for primary energy from 7.5 percent to 10 percent as well as goals for corresponding jumps in hydropower, wind power, solar power, biomass, and nuclear production capacity. These source-specific targets were noteworthy in their own right, but the figure that drew the most attention was a reduction of 20 percent in energy use per unit of gross domestic product (GDP) between 2005 and 2010. The 20 percent energy-efficiency target meant that China would go from 1.22 tons to 0.97 tons of coal per CNY10,000 of GDP, making 'it one of the most significant carbon mitigation efforts in the world (Jiang et al., 2007)'.

Because industry accounts for about 70 percent of China's total energy consumption, many of the specific actions adopted for the 20 percent energy-efficiency target aimed at making inefficient industries more efficient. These included: a program to close small enterprises; the energy conservation power-generation dispatch program; and the top-ten energy conservation projects. The centrepiece of these efforts was the 1000 Energy-Consuming Enterprises Program (Top-1000 Program).

This 'Top-1000 Program' allocated energy-saving targets to China's thousand highest energy-consuming enterprises in nine key sectors (iron and steel, petroleum and petrochemicals, chemicals, electric-power generation, non-ferrous metals, coal mining, construction materials, textiles, and pulp and paper). The enterprises were then called upon to establish an energy-conservation organization, energy-efficiency goals, energy-utilization reporting systems, energy-conservation plans, energy-conservation incentives, and energy-efficiency improvement options. Participating entities were further required to make quarterly energy-consumption reports to the National Bureau of Statistics (NBS) and sign conservation agreements with local governments. The agreements, in turn, helped evaluate the job performance of enterprise managers. Managers who made progress toward the targets could earn a pay raise or promotion; those who missed the mark could be denied such rewards or suffer even greater losses (Wang, 2009; Asian Pacific Energy Research Center, 2009).

The Top-1000 Program was not only important because it covered energy-intensive sources, but because it provided three additional insights into the nature of energy reforms in the 11th Five-year Plan. First, the majority of energy conservation measures focused on capturing efficiency gains from large energy-intensive sources. Second, the primary instruments for achieving these reductions were command–control regulations reinforced by provincial and national government investment programs (Price et al., 2009). Third and most importantly, the system that evaluated enterprise managers on their performance was nested in a larger system that evaluated provincial and city leaders on their performance in achieving the 20 percent energy-efficiency goals.

This last similarity meant that just as the Top-1000 Program held managers accountable for enterprise targets, a comparable system held subnational leaders accountable for local targets. As suggested in Table 12.1, the evaluation system used a 100-point scale to rate how well provincial leaders performed in meeting the targets. The results of these evaluations would then be used to determine promotions, honorary titles, and other rewards (Wang, 2009; APERC, 2009). Less than a decade ago, the same performance evaluation system encouraged subnational officials to pursue growth at all costs (Edin, 2004). Now it was reconstituted to hold leaders accountable for internalizing the costs of that growth.

In addition, some of this growth was being channelled into not only energy efficiency but renewables such as solar and wind. Renewables were never really on the policy agenda until 2005, but following the 2005–6

Table 12.1 Energy efficiency elements of China's evaluation system for subnational leaders

Assessment indicator	Points	Examination content	Scoring standards
Energy Intensity Target	40	Reduction of Energy Consumption per CNY10,000 of GDP	If the annual target is reached, 40 points will be allocated; if 90% of the target is reached, 36 points will be allocated; if 80% of the target is reached, 32 points will be allocated; if 70% of the target is reached, 28 points will be allocated; if 50% of the target is reached, 20 points will be allocated. If the target is exceeded, then for every 10% above target, 3 additional points will be awarded. This target takes precedence over the energy-consumption targets below.
	2	The Energy Efficiency Work of Organizations and Officials	1. Establishing the region's energy intensity statistics, monitoring and evaluation system: 1 point 2. Establishing an energy-efficiency coordination mechanism, a clear division of responsibilities, and regular meetings to study the major issues: 1 point
	3	Allocation and Implementation of Energy-Efficiency Target	1. Allocation of the energy savings target: 1 point 2. Carrying out an investigation and evaluation of progress in achieving the energy-savings target: 1 point 3. Regularly publishing energy consumption indicators: 1 point
Energy Savings Measures	20	Adjusting and Optimizing the Condition of the Industrial Structure	1. If the service sector accounted for an increased proportion of the region's GDP: 4 points 2. If the high-tech industry accounted for an increased portion of value-added production: 4 points 3. Developing and implementing energy-efficient and review procedures for fixed asset investment projects: 4 points 4. Completing the year's goal of eliminating retrograde production capacity: 8 points
	10	Energy Savings Investment and Implementation of Key Projects	1. Establishing special funds for energy-efficiency and sufficient implementation: 3 points 2. Increasing the proportion of fiscal revenue allocated for special energy-efficiency funds: 4 points 3. Organizing and implementing key energy-efficiency projects: 4 points

Continued

Table 12.1 Continued

Assessment indicator	Points	Examination content	Scoring standards
	9	The Development and Expansion of Key Enterprises and Industries	1. Including the energy-efficient technologies in the annual and science technology plan: 2 points 2. Increasing the annual proportion of fiscal revenue spent on energy-efficiency R&D: 3 points 3. Implementing energy-efficient technology demonstration projects: 2 points 4. Organizing and developing mechanisms to promote energy-efficient products and technologies and energy-efficient services: 3 points
	8	Managing the Energy Efficiency of Key Enterprises and Industries	1. If key energy-intensive enterprises (including the Top-1000 program) meet their annual energy-intensity targets: 3 points 2. Implementing the annual energy-saving monitoring plan: 1 point 3. Meeting the annual energy-efficiency target rate of minimum energy efficiency in newly constructed buildings: 4 points if 80% of the target is achieved, then 2 points; if less than 70% of the target is achieved, then no points
Energy Savings Measures	3	Implementing Laws and Regulations	1. Issuing and improving supporting regulations for the Energy Conservation Law: 1 point 2. Monitoring and enforcing the law with respect to energy efficiency: 1 point 3. Implementing standards that limit energy consumption for energy-intensive industries: 1 point
	5	Implementation of Basic Energy-Efficiency Work	1. Strengthening energy-efficiency modeling teams and institutional capacity: 1 point 2. Improving the system for energy statistics and institutional capacity building: 1 point 3. Installing energy measuring devices in accordance with the market mechanisms: 1 point 4. Carrying out energy-efficiency awareness and training: 1 point 5. Implementing the energy-efficiency incentive system: 1 point

Source: Wang (2009)

reshaping of China's regulatory framework, progress has been both swift and substantial. During the financial crisis, wind power was specifically held out as one of several industries that would provide China with growth through the global economic crisis (Wang, 2010; Zhang et al., 2010).

The seemingly simple shift in the energy structure and accountability mechanisms had significant implications. One of the more significant implications was a growing need for accurate energy data. In a typical case, the process of gathering this data began with provincial governments preparing and submitting a self-assessment report to the State Council and the National Development and Reform Commission (NDRC). Next, the NDRC and other related departments would verify implementation of reported data through spot checks and on-site investigations. The NDRC would then submit an examination report to the State Council before energy-savings figures were shared with the general public (Fei et al., 2009). This system had its roots in China's planned economy and gained newfound relevance with the energy reforms.

This relevance has become clearer as interest in the results to the 11th Five-year Plan's 20 percent energy-intensity targets (by 2010) has deepened. Recent reports suggest China's 19.06 percent reduction came just short of meeting the goal (Price et al., 2011). This shortfall must nonetheless be qualified by the fact that China's target was based on an assumed growth rate of 7.5 percent, whereas actual growth rates were 12.7 percent, 14.2 percent, 9.6 percent, 9.2 percent and 10.3 percent respectively (between 2006 and 2010). Other signs of progress were also apparent in other energy indicators during the 11th Five-year Plan. For instance, the NDRC suggested that China cut CO_2 emissions by about 1.5 billion tons because of the energy-saving and emission-reduction measures in its 11 Five-year Plan. Other reports suggest that investment in energy-saving and emission-reduction projects reached about CNY2 trillion ($301 billion).

But even as China made progress toward the goals in its 11th Five-year Plan, it also confronted several new challenges. For instance, some of the interviewees for this project noted that local-level leaders pursued their energy-intensity targets with too much enthusiasm. In the case of Hebei and Jiangsu provinces, for example, heightened pressure to reach the goals led to power being cut off from residential users in a series of rolling blackouts (Watts, 2010). In the case of Zhejiang Province, industries were forced to ration power and alter production schedules to keep up with pressures to conserve energy (Interview File 1).

Another set of concerns relates to the credibility of energy statistics. On this point, some observers have highlighted the discrepancy between central and provincial governments in the measurement of the energy targets. This added scrutiny reflects the need for greater accuracy, as rewards and punishments are linked to the targets (Economy, 2009; Interview File 3).

A final set of challenges involves the large, state-owned enterprises (SOE) that were the primary target of many of the 11th Five-year Plan reforms. One of the main reasons that China came so close to meeting its targets was that

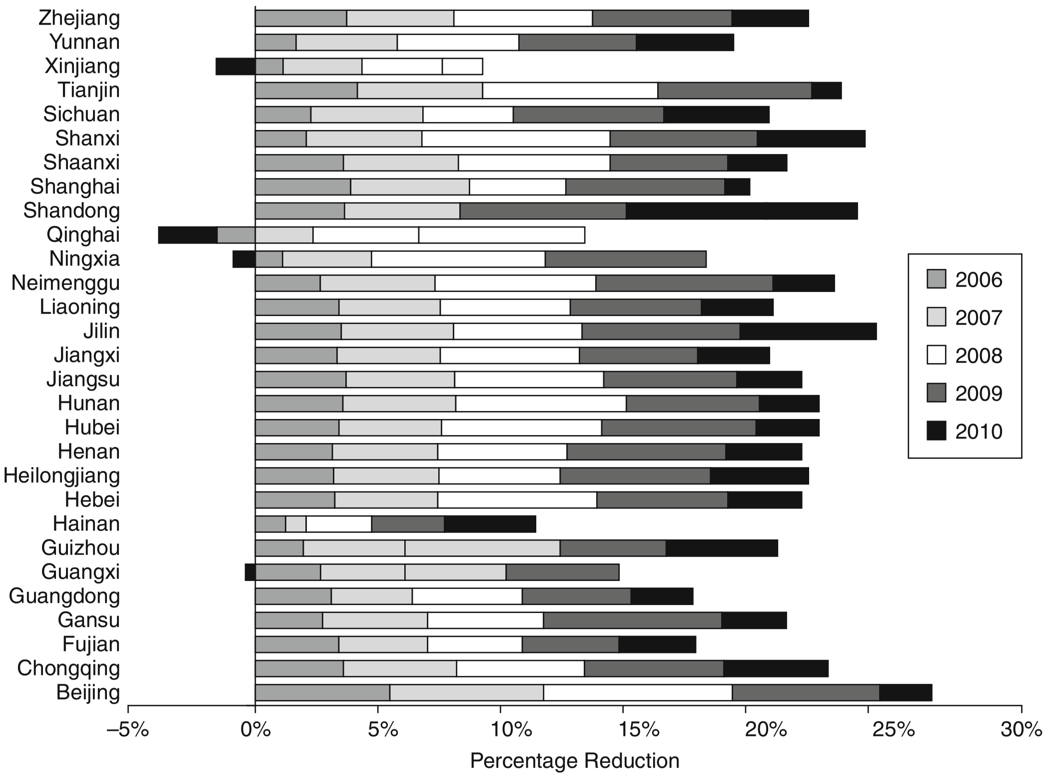

Figure 12.1 Progress made toward meeting China's energy-intensity targets, by province, in the 11th Five-year Plan (2006–10)

Note: The chart includes data through November 2010

Source: China's Statistical Yearbook (2007, 2008, 2009, 2010) it concentrated on low-cost abatement opportunities in the SOEs. The focus on these sources also raises the question of whether China could continue to rely on a similar set of motivating factors moving forward (Interview File 1). In other words, would political incentives tied to administratively set targets continue to yield reductions in the 12th Five-year Plan? The next section will suggest that international carbon markets, global measurement standards, and economic compliance incentives can strengthen national energy reforms that are gradually changing in scope and orientation.

The 12th Five-year Plan (2011–15)

There were important parallels between China's 11th and 12th Five-Year Plans. For instance, there was continued support from the top leadership (Hu Jintao and Wen Jiabao) who had begun to visit local areas to demonstrate their interest in energy-intensity targets.[1] The high-level discussion has been accompanied by a growing emphasis on changing the energy structure and improving energy efficiency by, for instance, identifying energy-intensive industrial sources and instituting familiar standards and measurement. Finally, as mentioned previously, in the lead-up to the COP 15 Hu Jintao announced that China would reduce its carbon intensity by 40–45 percent from a 2005 base year by 2020. This goal has since been linked to the chapeau (introductory text) of the Copenhagen Accord and the INF document in the Cancun Agreements (a document listing pledged mitigation actions from 47 developing countries).

These similarities notwithstanding, perhaps the most striking parallel is that China decided that the 12th Five-year Plan would include a 16 percent target for reductions in energy consumption per unit GDP. The new target would be accompanied by reductions in the percentage of coal use as a proportion of primary energy from 70 percent to 62 percent and a greater reliance on hydro power (to reach 380 GW by 2020), nuclear power (to reach 80 GW by 2020), as well as wind, solar, and biomass (to collectively reach 200 GW by 2020). While this amounts to less than a structural change within energy production, it is worth noting that wind, solar and biomass now go by the label of 'new strategic and emerging industries' that will be promoted in order to replace the 'old pillar industries' (including coal and oil) (Lewis, 2013; Qin, 2010).[2]

Even with these parallels, there are also important differences between the 11th and 12th Five-year Plans. Among the most important is a deliberate effort to tailor the allocation targets for reducing energy consumption to the specific characteristics of each local region, including the stage of economic development and the level of fulfillment in the past five-year plans. The provinces have been divided into five groups based on these criteria (See also Figure 12.2):

Another key difference is an effort to reduce fast-growing emissions at the urban level, exemplified by pilot programs for low-carbon provinces and cities. In August 2010, the NDRC issued 'The Notice to Establish and

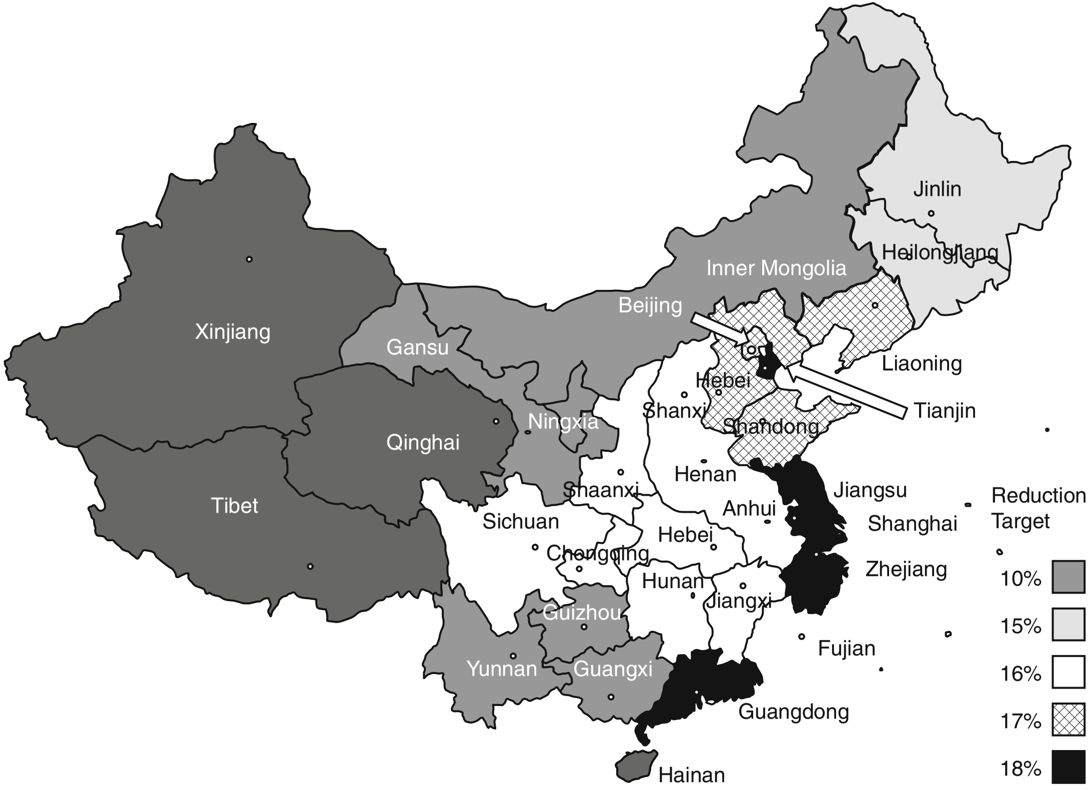

Figure 12.2 China's carbon intensity target in the 12th Five-year Plan

Source: State Council (2011).

Develop Low-Carbon Pilot Provinces and Cities'. The notice clarified that China would set up low-carbon models in five provinces (Guangdong, Liaoning, Hubei, Shanxi, and Yunnan) and eight cities (Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang, and Baoding). Each province and city was then called upon to craft and implement plans based on different regional characteristics. For instance, Guangdong Province released a series of targets and tasks compatible with its energy structure (Interview File 4). Other participating governments have been requested to submit implementation plans that accelerate low-carbon industries, establish GHG emission data systems, and advocate low-carbon lifestyles and consumption patterns (Wang et al., 2010; Wang, 2011). Equally revealing is that outside the formally sanctioned low-carbon cities, other local governments have taken it upon themselves to promote low-carbon development. These include cities such as Wuxi, Jiangsu Province that is home to Suntech, the world's largest solar panel manufacturer (Interview File 9).[3]

Although low-carbon pilots have been launched in some cities, and planning has commenced in others, many issues remain unsettled. First, there is lack of low-carbon standards (although the National Bureau of Statistics (NBS) is developing a monitoring system for carbon emissions, low-carbon technology, and industrial standards). This will become increasingly important as governments try to translate low-carbon visions into sector-specific actions. Second, low-carbon programs will need to accommodate different geographic features, levels of development, and industrial structures; a lack of planning experience and administrative capacity may make it challenging for local-level officials to develop a context-appropriate low-carbon policy. Third, a lack of capacity could also prove problematic because the transportation and building sectors account for a significant share in cities, but require comparatively greater monitoring costs than the SOEs that were targeted in the 11th Five-year Plan.

In addition to low-carbon pilots, another potentially critical difference is the consideration of market-driven instruments such as emissions-trading schemes. The decision to introduce a trading program was made at a meeting hosted by the NDRC in 2010. Since that decision, there has been a careful examination of the experience of the European Union with its emissions-trading scheme. Now, in the summer of 2013, China's first-ever carbon-trading program will begin in the city of Shenzhen. More cities and provinces will follow in a pilot program that will be completely implemented by 2014 (Climateprogress, 2013).[4] By relying on the market-clearing prices rather than administrative fiat, a carbon-pricing scheme could be a cost-savings departure from current command–control efforts to boost energy efficiency (Li, 2010).

But, similar to low-carbon pilots, emissions trading also confronts a series of challenges. First, institutional reforms will be needed to create, allocate, and enforce emissions permits. The design of this supporting enabling environment can be an easily overlooked element of a trading program; and China does not yet have the software or hardware at the source level to monitor emissions (current practice is based on fuel-consumption figures). Second, the carbon intensity target will have to be converted to allowances for trading. This will also require difficult calculations and likely result in lengthy negotiations with participating sources. Third, there must be a sufficiently large number of participants with varying abatement costs to ensure the purchase and trading of emissions. The limited number of sources and demand hampered China's piloting of an SO_2 emissions-trading program; they could pose a similar barrier for carbon (Interview File 5). Finally, there are still significant differences between various government agencies on how to handle these issues. The difficulties of finding an acceptable compromise could delay program rollout and undercut faith in the program (Interview File 5).

A final area where there may be a departure from the current set of command–control regulations is a carbon tax (Jones, 2010). During the 12th Five-year Plan, China may start levying a carbon tax to cut emissions, drawing experience from a resource tax that is currently being piloted on fossil fuels in Xinjiang (Interview File 5). Some have recommended beginning to levy the tax at $1.45 per tonne of CO_2 emitted, rising incrementally to between $7.30 a ton and $59 per ton by 2020 (Interview File 2). A portion of the revenue would then be funneled back into energy-saving investments and local governments for their own low-carbon initiatives (Young, 2010). The tax reforms may also include exceptions or subsidies for vulnerable industries and would fit easily into existing institutional arrangements.

Yet, echoing a familiar theme, the carbon tax also appears likely to encounter challenges. These include that the tax must be set low enough to be politically acceptable, but high enough to induce changes in behavior. There is obvious opposition to a carbon tax, so it is not a given that it will happen,[5] but a system could be in place by 2014, with levies expected at CNY5–10 per tonne of carbon (roughly $0.80–1.60). However, for the tax to have much of an impact on carbon emissions, it ought to be set at least twice as high. Another potential point of contention is whether the tax would be assessed on the energy source, such as the power plant or, further upstream, the coal mine. Finally, the tax will have to accommodate an evolving regulatory landscape that could include: command–control regulations on large industrial sources; low-carbon pilots in select cities and provinces; and emissions-trading programs at the source or regional level. The sheer number of programs could present a non-trivial coordination problem.

This final challenge is worth highlighting because it applies not only to carbon taxes, but other options being considered for the 12th Five-year Plan. To a certain extent, the variety of regulatory approaches is necessary to capture higher-hanging fruit in China's energy sector. But to a comparable degree, they point to a central difficulty: namely that the changing scope and orientation of regulatory reforms may require a different set of enabling conditions to register as much progress as in the 11th Five-year Plan. In this chapter we argue that developments at the international level may help address these needs.

Changing the incentives

The decade between 2010 and 2020 will be a critical juncture for China. Decisions on industrialization and urbanization will influence energy use and consumption for years to come. Some studies have shown the feasibility of low-carbon plans that diverge sharply from business-as-usual projections. The most optimistic of these scenarios outlines an enhanced low-carbon (ELC) scenario that entails GHG emissions rising through 2030 and then dropping sharply thereafter. Driving this scenario are: (a) the development of new technologies, expanded dissemination of low-cost technologies, and lower efficiency losses in existing technologies; (b) research and development and capital investment to support a low-carbon society; (c) advanced energy diversification (including a significant increase in renewables); (d) dissemination of clean-coal technology and carbon capture and storage (CCS); and (e) enhanced international cooperation (Jiang et al., 2009; Asuka et al., 2010). While the first four elements of this scenario will clearly be crucial, the focus of the remainder of this chapter focuses on how international cooperation can enable China's low-carbon transition.

At COP 16 in Cancun, negotiators made progress on key elements of a future climate regime. This progress is evident in the linkages between key reforms in the climate regime and corresponding challenges in China. Moving forward, there will clearly be a need for a financial mechanism that can accommodate not merely projects but programs and policies. The need for a wider range of activities has been recognized in recent climate negotiations. In fact, as initially spelled out in the Bali Action Plan (COP 13) and then reiterated in the Copenhagen Accords (COP 15) and Cancun Agreements (COP 16), developing country participation for the 2012–20 period will involve pledging nationally appropriate mitigation actions (NAMAs) and receiving financial, technological or capacity-building support for some those actions. Some of the proposed support will flow through a Green Climate Fund with thematic windows. The Green Climate Fund is supposed to help allocate a portion of up to $100 billion in climate finance annually by 2020.

Those funds could then be allocated to NAMAs that include a well-integrated set of policies targeting carbon reductions in China's cities. It could also strengthen the capacity to plan and implement low-carbon reforms at the urban level (Fei and Gu, 2007). If these funds moved through a new market mechanism, they could expand the pool of purchasers, creating more demand than found in the SO_2 emissions trading program (Interview File

5). The biggest advantage is that China can remain engaged in the carbon market, especially if the CDM market disappears.

Yet another reason is the changing nature of compliance incentives necessitated by a greater reliance on market-based regulations. China has already begun considering ways to refine its performance-evaluation system so as to avoid the rolling blackouts and other undesirable consequences. For instance, the allocation of targets in the 12th Five-year Plan has been based more on economic modeling, a broader number of indicators, and shorter time increments. The government is already listening to academic proposals on a more rational way of allocating 12th Five-year Plan targets to provincial leaders (Interview File 2, see also Yi, 2011, for a discussion of the 2020 targets). But as China begins to develop a more varied regulatory landscape, economic, as opposed to political, incentives will need to play a role in incentivising compliance. It is further noteworthy that pilot trading programs China is contemplating will require a different set of incentives. This is because, under an emissions-trading scheme, a source that fell short of a target would be expected to purchase credits from another source. This starkly contrasts with the current point-based system for enterprise managers and government officials.

China's low-carbon reforms also require more accurate measurements of emissions. For example, since many urban-level reforms involve transportation and infrastructure, standards and monitoring protocols will have to accommodate dispersed sources. Similarly, the use of market mechanisms would also necessitate precision in measurement. In Cancun it was agreed that developing countries will report progress of NAMAs with 'a process for ICA of biennial reports in the Subsidiary Body on Implementation, in a manner that is non-intrusive, non-punitive and respectful of national sovereignty' (United Nations Framework Convention on Climate Change, 2010). Provided that it is non-intrusive, non-punitive and respectful of nations, the ICA process will also increase incentives for better data and standards for reporting.

The way forward

This chapter has argued that both China and the international community have much to gain from parallel developments in national energy policy and the international climate regime. While the 11th Five-year Plan focused chiefly on capturing efficiencies in large state-owned industrial sources, the 12th Five-year Plan provides early indications of an energy policy that will target a broader array of sources with a more varied set of regulatory instruments. These changes will also require significant, although underappreciated, reforms to China's enabling environment. Clearly, some of these reforms can happen within China; but just as clearly it will be difficult to institute reforms through a policy-making system structured around linking political incentives to planned targets for large sources. It is no surprise that these systems are typically better at preserving the status quo than enabling significant deviations from business as usual.

There is also much that China and the international community can do to support the gradual alignment between national policy and international climate architecture. For example, China tends to introduce ambitious pilots before formally embracing a new policy idea. For those unaccustomed to this policy-making style, there is significant scope for disappointment when the policy moves forward slowly or does not perform up to expectations. Especially when it comes to climate change, it is important that China communicate that a new initiative is still being tested. This will help keep expectations in check. At the same time, it would also be useful if the international community provided incentives for trying new approaches. One much-discussed possibility would be the creation of a no-lose sectoral crediting mechanism for China's NAMAs. Such a mechanism would allow China to pledge pilots and receive financing for any reductions above and beyond an ambitious baseline. It could hold out economic carrots and help rebuild some of the trust that was lost in Copenhagen (and partially recovered in Cancun).

Building trust will also be crucial to sustaining the momentum beyond the somewhat lukewarm results of COP 17 and 18. This will be inherently difficult for a China that is still learning how to use its new-found power in the international system. There is nonetheless a growing incentive to wield that power in a way that benefits China and the global climate. Both China and the international community should look for small steps toward more significant progress.

Interview file

Interview File 1	Researcher/Professor Major University Beijing
Interview File 2	Researcher Think Tank Beijing
Interview File 3	Professor Major University Beijing
Interview File 4	Researcher Think Tank Beijing
Interview File 5	Professor Major University Beijing
Interview File 6	Program Officer Development Bank
Interview File 7	Representative International NGO
Interview File 8	Professor Major University Beijing
Interview File 9	Researcher International Think Tank, Beijing
Interview File 10	Researcher Think Tank Beijing
Interview File 11	Professor Major University Beijing

Notes

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1. Another indication of leadership support is the current discussion over a 'Law of Addressing Climate Change'. In an effort to consolidate policies related to climate change, the NDRC is required to draft a new Climate Change Law in the next two to three years. The NDRC has been collecting inputs on the law since March 2011; sources indicate passage of the legislation could come in 2015.
2. The target for solar PV has since then been adjusted upwards 50 GW by 2020, up from originally 20 GW (Huo and Zhang, 2012; Liu and Goldstein, 2013).
3. Suntech recently went bankrupt, showing that Chinese manufacturers are by no means impervious to global pressures and changing market conditions. It was, however, more or less immediately rescued by the Wuxi city government.
4. Seven pilot carbon-trading programs will be set up in Beijing, Shanghai, Shenzhen, Guangdong, Tianjin, Chongqing and Hubei, regulating 800 million to 1 billion tons of emissions by 2015. This will make the program second only to the European one (Bloomberg, 2013).
5. The postponement of the introduction of the tax from 2013 to 2014 is allegedly because of concerns that economic growth would suffer (Bloomberg, 2013). While it has been relatively easy for China to implement legislation in times of rampant growth, it will be interesting to see if China can continue to move ahead on its low-carbon agenda, also in a context of weaker future growth.

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13

The German Policy Support Mechanism for Photovoltaics: The Road to Grid Parity

Karolina Jankowska

Introduction

In the past decade, Germany has become the world leader in photovoltaics (PV) promotion via an aggressive national feed-in tariff (FIT) policy. This chapter traces the evolution of the German solar PV promotion policy since 1990, highlighting the major policy innovations implemented by German policy-makers. The chapter discusses the major design features creating investment security for the German PV sector: a purchase obligation for renewable electricity, cost-based tariff levels, priority grid access, and tariff degression. In addition, the chapter discusses the major policy amendments in 2000, 2004, 2009, 2010, 2011 and 2012.

The German support framework has explicitly been designed to drive PV costs down its learning curve. Although PV has historically had higher costs than other energy technologies,[1] prices have dropped considerably over the past decade (by more than half even over the past couple of years). The recent FIT amendment/proposal offers tariffs which are below retail electricity prices. The chapter closes by analyzing critical points of the current and potential implications for the future design of support policies for PV in Germany. It argues that over the past decade the German policy-support mechanism for PV has become more difficult to estimate, offering less transparency, longevity and certainty to investors. The reason is that over the last couple of years the feed-in rates and the degression schemes have been changed many times spontaneously as an ad hoc reaction to PV market development and declines in PV module prices, and sometimes even have been backdated. One reason is the emergence of competitors from China, which accelerated rapid PV price declines. Another reason is the existence of rival advocacy coalitions in the German energy-policy formulation process, namely conventional power companies and different industrial actors on the one hand and the renewable energy industry on the other hand. Especially since the government change – in 2005, after seven years in power, the coalition of the Social Democratic Party (SPD) and the Greens, which created and adopted the FIT policy in the first place, was replaced by a Christian Democratic Union/Christian Social Union (CDU/CSU)–SPD coalition, followed by the CDU/CSU and the Free Democratic Party (FDP) coalition – Germany is again more supportive of the big, conventional energy industry as well as energy-intensive companies.

Nevertheless, the PV market in Germany is continuously growing, and it poses great challenges for decision-makers with respect to on-site power consumption, PV market integration, wholesale grid parity and the increasing amount of fluctuating electricity supply from PV.

Feed-in tariff – the key driver of renewable energy development in Germany

On September 28, 2010 the German government adopted a comprehensive energy concept for an environmentally sound, reliable and affordable energy supply (Federal Ministry of Economics and Technology [BMWi], Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU], 2010). Compared to 1990, by 2020 carbon emissions should decrease by 40 percent and by 2050 by at least 80 percent. In order to meet these targets renewable energy in the electricity sector should be further developed. By 2020 the share of renewable electricity in gross electricity consumption should amount to at least 35 percent; by 2030 at least 50 percent; by 2040 at least 65 percent; and by 2050 at least 80 percent. For renewable electricity to have such a large share of electricity consumption in Germany it needs an effective and efficient support mechanism (Bundesregierung, 2011, p. 3). The Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz* [EEG]) has proved very successful since its adoption in 2000: it managed to increase the share of renewable electricity from 6 percent in 2000 to more than 15 percent in 2008 (Mendonça et al., 2010, p. XIII). Internationally, Germany's development tempo is unprecedented: in contrast to Germany the share of renewable energy has changed only a little in the world and the increasing share of renewable energy in the EU is due to the German development (Bundesregierung, 2011). But what has been the key driver behind it?

The main support-policy mechanism responsible for the success of renewable energy in Germany is the FIT scheme, on which the German Renewable Energy Sources Act is based. According to German Bundestag member Hans-Josef Fell, who wrote the draft of the EEG, the FITs have proven to be the best support mechanism to rapidly increase the share of renewable energy supply (Mendonça et al., 2010, p. XII; Bechberger and Reiche, 2006, p. 206). Therefore it has become the most important climate-protection tool (at least in the EU), far more effective than the EU Emissions Trading Scheme. In 2011 it helped to avoid around 130 million tons of greenhouse-gas emissions. Moreover, in Germany in 2009 it contributed to the creation of at least 300,000 direct and indirect jobs (50,000 in the PV industry in 2008), to the avoidance of energy imports worth about €5.1 billion and to approximately €3.6–4 billion in savings to electricity customers or suppliers due to the merit-order effect (BMU, 2010, p. 6; Solarserver, 2009).[2] Even more important is, however, the comparison of the costs and benefits of the EEG: '[A] rough calculation of the existing quantitative system costs in the heat and power sectors reveals total costs of around EUR 7.5 bn (6 bn) for 2009 (2008). This compares with a quantified gross benefit for the same year of some EUR 8 bn (also in 2008)' (BMU, 2010, p. 6).

The German FIT scheme is a good example of how a country can address climate-change concerns, while at the same time creating jobs, improving energy security and economic growth by expanding its own renewable energy sources. All this is the result of the good design of the German FIT scheme, which can be perceived as an example of a best practice (see for instance Mendonça et al., 2010). Nevertheless, recent changes to the EEG have brought about much criticism from actors making the point that the changes are preventing the fulfillment of the already-announced national project of the *Energiewende* (energy transition).

Generally, a successful FIT scheme should establish an economically affordable, legally supported and politically palatable way to finance renewable energy production by the energy industry (Jankowska et al., 2008, p. 3). It should also include the following design features (based on: Mendonça et al., 2010, pp. 36–37; Jankowska et al., 2008, p. 3; Bundesregierung, 2011, p. 4):

- determining which technologies shall be eligible based on the resource availability in a country or region,
- determining which kind of power production plants shall be eligible,
- establishing a transparent tariff-calculation methodology based on the generation costs of each technology,
- setting technology- and size-specific feed-in rates that encourage investments,
- sharing the additional costs among all electricity consumers (surcharge – in German *Umlage* – in the case of the EEG it is the difference between the feed-in rate and the electricity price on the stock market),
- fixing the duration of tariff payment (usually 20 years) and its yearly degression, providing the renewable energy producer with the investment security and the incentive needed to further reduction of technology costs,
- obliging the grid operator to purchase all renewable electricity,
- granting priority grid access, transmission and distribution to electricity from renewable energy sources,
- obliging the grid operator to connect the renewable energy plants to the grid and eventually to modernize and extend the grid if necessary.

In this chapter the focus is on PV, which is a particularly attractive technology by which solar energy can be converted into electricity (Jankowska et al., 2008, p. 1). The Scientific Council of the German Federal Government Global Environmental Changes (*Wissenschaftlicher Beitrat der Bundesregierung Globale Umweltveränderungen*) predicts that solar energy (solar thermal energy and PV) will become an increasingly important energy source in the future. Since the 2000 introduction of the Renewable Energy Sources Act and 2004 amendment, Germany has seen its greatest growth yet in the use of PV to meet its domestic demand for electricity (Jankowska et al., 2008, pp. 1–2). Nowadays, Germany is a global leader in installed PV capacity – almost a half (45 percent) of the world's PV capacity is currently installed in Germany (25 GW). Nevertheless, its support has caused a very controversial debate during the last few years.

Historically, in Germany the cost of green electricity has been 2–4 times higher than conventional electricity, with PV being the most expensive renewable energy technology (in the year 2000, tariff payments amounted to more than 50 ct/kWh). An important goal of German renewable energy policy has therefore been to lower the costs of PV as well as other renewable energy sources through enhanced production to the point that such support was eventually no longer necessary, and hence grid parity achieved. The recent FIT tariff amendment that offers tariffs for PV below retail electricity prices shows that the point of retail grid parity at which PV becomes competitive with the electricity purchased by end consumers from the grid has been theoretically achieved. In reality the grid parity differs on a case-by-case basis determined by a broad range of factors, including project costs, PV system output and the retail rate. It is more difficult to project when wholesale grid parity is achieved, because the future wholesale price trends are unclear, and renewable energy is suppressing the wholesale electricity price due to the merit-order effect (DB Climate Change Advisors, 2012, pp. 23–4).

Of special note is that already more than 40 states, countries or regions in the world have adopted some version of the FIT scheme. Although not all of them have been as successful as the German FIT scheme, all of them have enabled much quicker, more affordable and more sustainable growth in clean-energy industries than alternative support schemes (Mendonça et al., 2010, p. XV). Thus, another purpose of this chapter is to present the German solar success story with a view of providing policy ideas and recommendations for consideration by policy-makers interested in implementing new policies based on the German experience.

History of German renewable energy policy and politics for PV

1990– Electricity Feed-in Law (*Stromeinspeisungsgesetz* [StrEG])

After the nuclear accident in Chernobyl in 1986 and the works of the second Climate Survey Commission (*Klima-Enquete-Kommission*) acceptance increased for the promotion of renewable energy in Germany. In 1989 the Federal Ministry of Research started the 1,000 Roofs Program to support the fitting of 1,000 roofs with PV by providing low-interest financing, which was a great step towards the market development of this technology. However, for further development more support was needed. This led to the implementation of the Electricity Feed-in Law, or *Stromeinspeisungsgesetz* (StrEG), in 1990 by the coalition government of the CDU/CSU and the FDP (1987–98), which introduced Germany's first FIT scheme at the national level. It already consisted of two important elements of the later EEG, namely the purchase obligation for renewable electricity and cost-based tariff levels (Hirschl, 2008, p. 133; Bundestag, 1990). Under the StrEG, PV was eligible for a FIT payment set at 90 percent of the retail electricity rate (Bundestag, 1990), which meant that the feed-in rate fluctuated between 8.45 and 8.84 ct/kWh over the course of the decade (DB Climate Change Advisors, 2011, p. 15). The FIT costs were recovered regionally by the local energy utilities. In 1998 two hardship clauses favoring these utilities were introduced into the StrEG. Due to the first, the local utilities were only required to recover policy costs up to a 5 percent renewable energy penetration level, whereas the rest was to be paid by the grid operators. The second advantageous rule for the energy utilities was the exemption from renewable energy purchases if the costs for end consumers increased too much (Bundestag, 1990).

The support provided by the StrEG was, however, not high enough to induce rapid development and economic operation of PV installations. Since the payment was the same for cheaper wind energy, the first German FIT benefited wind energy more than PV. Therefore stronger support instruments were needed. Thus, the German government introduced the possibility for PV generators to receive rebates equal to 70 percent of system cost (starting in 1990) besides the already-mentioned support via the 1,000 Roofs Program (DB Climate Change Advisors, 2011, p. 15). However, the short-term market development of PV stagnated after the 1,000 Roofs Program ended in 1995 (Hirschl, 2008, p. 134).

The capacity of PV increased during the decade following the introduction of the StrEG, but it was still rather low in comparison to water and wind power – by the end of 1999, 58 MW of PV had been installed, in comparison to 4,547 MW of water and 4,444 MW of wind power (Hirschl, 2008, p. 139).

2000– Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz* [EEG]) and its amendment in 2003

Further renewable energy policy development resulted in stronger PV support. The 1998 parliamentary election led to the establishment of a coalition government of the SPD and the Greens (1998–2005), which gave a strongly renewed impetus to climate policy (Jänicke, 2011, p. 133). In 2000 this coalition adopted the decision to phase out nuclear energy (*Atomausstieg*) in Germany. The intensive negotiations over *Atomausstieg*, which took place in parallel with the policy process towards the EEG, placed further pressure on policy-makers to enhance energy efficiency and improve the market competitiveness of renewable energy sources. In 2000 the coalition government introduced the Renewable Energy Sources Act, which maintained a feed-in-tariff scheme (Jankowska et al., 2008, p. 2). The EEG was based on the StrEG, but revised and further improved it. The EEG first introduced national feed-in rates that approximated the generation costs of PV systems and proved more effective than a direct linkage of incentives to retail rates (DB Climate Change Advisors, 2011, p. 15). The reason was that the feed-in rates, which were linked to the electricity price, became very low as the EU power market liberalization led to electricity prices dropping sharply (Hirschl, 2008, p. 141).

The generation cost method introduced by the EEG set a targeted internal rate of return – approximately 5–7 percent – in order to reduce investment risks (DB Climate Change Advisors, 2011, p. 15; see also BMU, 2007). As a result, the feed-in rates paid to PV generators were higher than under the StrEG (Jankowska et al., 2008, p. 2). The lowest PV feed-in rate amounted to 0.99 DM/kWh (Bundestag, 2000), or roughly 0.51 ct/kWh (DB Climate Change Advisors, 2011, p. 16). Moreover, the feed-in rates were guaranteed for 20 years, but were reduced yearly by 5 percent (Bundestag, 2000) in order to drive PV costs down its learning curve. According to the EEG, the feed-in rates are reviewed every four years. Also, a nationwide financing mechanism was put in place, with the aim of providing fair burden-sharing of FIT costs among all energy utilities in the German power market (the so called *EEG-Umlage* – see above 'surcharge'). These costs were passed on to energy consumers.

Initially the law introduced a hard cap at 350 MW of capacity. If the cap were reached, new feed-in rates would be calculated so as to provide proper conditions for the economical operation of the PV systems, while at the same time taking into account their costs degression (Bundestag, 2000). The hard cap was amended in June 2002 and increased to 1,000 MW, because the previous cap was expected to be reached in 2003. By the end of this year PV capacity had already reached 435 MW (DB Climate Change Advisors, 2011, p. 16; Hirschl, 2008, p. 155). A large part of this capacity growth, however, has to be put down to the 100,000 Roofs Program which since 1999 offered zero-interest loans from the government-owned Reconstruction Credit Institute (*Kreditanstalt für Wiederaufbau*). Because of the massive PV market development in 2002 and 2003, the Federal Ministry of Economy forecasted in its EEG Report that PV systems prices would drop to a great extent and suggested that from 2004 PV should be supported exclusively by the EEG, which meant ending the 100,000 Roofs Program (Hirschl, 2008, p. 154).

Since the introduction of FITs in Germany, there have been many opponents, especially from within the conventional energy industry, criticizing it for being unauthorized state aid (Jacobsson and Lauber, 2006, p. 267). This criticism could, however, be ignored ever since the European Court of Justice declared in March 2001 that the EEG does not qualify as state aid. As a result of this decision, the EU Directive 2001/77/EC on the promotion of electricity from renewable energy sources (European Parliament and Council, 2001), and the dynamic renewable energy market development in Germany, the EEG has become an internationally renowned example of renewable energy policy, being emulated in more or less revised versions in many other countries within the EU and worldwide. However, the national industry remained very critical towards the EEG, mainly because of the *Umlage* and did not give up on trying to reshape it to their own advantage. The first concrete proposal concerning the possible change of the EEG came from the energy-intensive industry, which demanded an exemption from the *EEG-Umlage*. As a consequence, in 2003 a hardship clause (the so-called *Härtefallregelung*) was introduced, according to which industry companies consuming more than 100 GWh per year were allowed to cap their additional costs stemming from the *EEG-Umlage* to a level of 0.05 ct/kWh (Hirschl, 2008, pp. 156–7).

EEG 2004 – improvement of the feed-in rates

After the 2002 publication of the EEG Report of the Ministry of Economy and the expiry of the 100,000 Roofs Program, it became clear that the EEG, especially the feed-in rates, should have been revised and improved. Without the financing from the 100,000 Roofs Program the PV systems could not be operated economically under the EEG 2000. The 100,000 Roofs Program was also criticized due to some difficulties that it caused at the power market, for example through the dependence of the state budget (Hirschl, 2008, p. 159). Therefore there were voices suggesting its replacement by an extended support through the EEG. The revisions to the EEG with respect to PV feed-in rates were made by the SPD and Green Party coalition government in 2003 and went into effect in January 2004. It took place one year ahead of schedule in the form of a so-called *Vorschaltgesetz* – (an advance law, a stopgap measure passed in anticipation of a more thorough reform (Jacobsson and Lauber, 2006, p. 268)) – before the adoption of the amendment of the EEG following in the same year, in order to provide the PV investors with further regulation after the 100,000 Roofs Program expired (Hirschl, 2008, p. 159).

The improved feed-in rates for PV were differentiated by system size and by application type (façade-mounted, roof-mounted or free-standing) and ranged from 46 to 62 ct/kWh. The 1,000 MW cap was removed. The annual degression was changed for the free-standing systems and amounted to 6.5 percent starting in 2006 (Bundestag, 2004, pp. 7–8; Climate Change Advisors, 2011, p. 16).

Under the amended EEG, growth in the PV market accelerated, with cumulative capacity expanding to 5,979 MW by the end of 2008 (DB Climate Change Advisors, 2011, p. 16). From 2005 to 2007, annual PV growth was as much as 50 percent, constituting the second-highest growth rate among climate-related technologies in Germany, beaten by solar thermal heating only (Jänicke, 2011, p. 139). Altogether, in 2006 about 2 billion kWh of electricity was generated from solar PV installations, which amounted to 3 percent of renewable electricity production and 0.3 percent of the whole German electricity supply (Hirschl, 2008, p. 164).

EEG 2009 – introduction of a flexible degression system

In July 2008 once again the EEG was revised, with new feed-in rates put in place in 2009. The revision was undertaken by the grand coalition government comprised of the CDU/CSU and the SPD (2005–9). The three main reasons for the revision were the rapid declines in PV module prices and the need to reduce the overall costs of PV development for the end consumers, as well as a threat to grid stability posed by the rapidly increasing share of solar electricity (Schultz, 2011). The new feed-in rates ranged from 31.94 ct/kWh to 43.01 ct/kWh, depending on the system type and size (Bundestag, 2009, pp. 16–17). New annual feed-in degression rates ranged from 8 percent to 10 percent in the years 2010–11 (Bundestag, 2009, p. 11). The revision also introduced a volume-management strategy based on the 'corridor' or 'flexible' degression system for PV whereby the feed-in rate would be additionally decreased or increased each year depending on the capacity installed during the previous year. The degression would be increased by 1 percent if the capacity installed were higher than 1,500 MW in 2009, 1,700 MW in 2010 and 1,900 MW in 2011. The degression would be decreased by 1 percent if the capacity installed were lower than 1,000 MW in 2009, 1,100 MW in 2010 and 1,200 MW in 2011 (Bundestag, 2009, p .11). In order to track the installed capacity the amendment established an obligation for all FIT applicants to register their systems with the Federal Network Agency (*Bundesnetzagentur*) (BMU, 2012a).

The 2009 EEG amendment also introduced the first incentive for direct sale of renewable electricity on the wholesale market. Since then electricity producers have been exempted from the whole EEG surcharge if they sold at least 50 percent of the electricity from renewable energy on the wholesale market, including at least 20 percent electricity from wind or solar energy (the so-called *Grünstromprivileg*). It also introduced a feed-in rate on top of the retail electricity rate (25.01 ct/kWh) for electricity consumed onsite from PV systems with an installed capacity lower than 30 kW (Bundestag, 2009, p. 17). Due to the accelerated development of the PV market in Germany, in 2009 alone 3,806 MW of PV was installed (DB Climate Change Advisors, 2011, p. 16), more than in any previous year.

EEG 2010 – two non-scheduled reductions of the feed-in rates

Since, from 2009 to 2010, the PV capacity installed exceeded the projected 1,500 MW, feed-in rates were decreased by 7.5 percent. However, due to further rapid declines in PV module prices the coalition government of the CDU/CSU and the FDP (2009–2013) called for additional cuts beyond this reduction. In July 2010 the government passed a law to decrease feed-in rates for building-mounted systems by 13 percent, for ground-mounted systems by 8–12 percent (backdated to 1 July 2010) and in October 2010 for all systems by 3 percent (DB Climate Change Advisors, 2011, p. 17; Bundestag, 2010, pp. 19–20). Moreover, it also revised the corridor degression system for the year 2011. However, the degression of feed-in rates in 2011, calculated on the basis of the 2010 PV capacity development, should have had to be announced by October 31, 2010. In order to calculate this degression the capacity of all systems registered by the Federal Network Agency between May 31 and October 1, 2010 was therefore multiplied by three. The degression would be increased by 1 percent if the capacity installed was higher than 3,500 MW, by 2 percent if the capacity was higher than 4,500 MW, by 3 percent if the capacity was higher than 5,500 MW and by 4 percent if the capacity was higher than 6,500 MW. The degression would be decreased by 1 percent if the capacity installed was lower than 2,500 MW, by 2 percent if it was lower than 2,000 MW and by 3 percent if the capacity was lower than 1,500 MW (Bundestag, 2010, pp. 18–19).

In spite of the further reduction of PV feed-in rates in 2010, 7.4 GW of PV was installed, compared to government projections of 6 GW (DB Climate Change Advisors, 2011, p. 17). However, the PV growth could probably have been even higher and the PV systems would have reduced the electricity price further through the merit-order effect if policy changes reducing PV market growth had not been put in place (Solarenergie-Förderverein Deutschland e.V., 2010).

EEG 2011 – degression split into two parts

The next amendment of the EEG with respect to the degression schedule for PV feed-in rates was adopted in February, 2011. It was motivated once again by a very dynamic expansion of solar power in Germany, again far exceeding expectations (BMU, 2011), as well as by the necessity of reducing costs of PV support for electricity consumers and lowering the risks for grid stability. Therefore the additional feed-in rates reduction for building-mounted systems originally planned for January 1, 2012 was brought forward and became effective on July 1, 2011. The potential degression for 2012 was split into two parts: the first occurred on July 1, 2011 and was based on the additional capacity installed between March and May 2011 multiplied by four. The reduction could total up to 15 percent by mid-2011 (BMU, 2011; DB Climate Change Advisors, 2011, p. 17; Kabinett, 2011). The second degression occurred on 1 January 2012 and was based on the amount of capacity installed between October 2010 and September 2011, to compare with the projection made in July 2011. The total degression for 2012 should have amounted to between 1.5 percent and 24 percent (DB Climate Change Advisors, 2011, p. 18; Kabinett 2011). For free-standing installations, the reduction took effect on September 1, 2011 (BMU, 2011).

By 2011, in spite of the further PV feed-in rates reduction, 25,000 MW of PV had been installed in Germany, of which more than 8,000 MW were installed in 2011 alone. This meant that at the peak, during sunny summer days, solar power might provide an astonishing 40 percent of power demand (Morris, 2012).

EEG 2012 – reduction, degression and introduction of the market integration model

On June 30, 2011 the German parliament adopted a comprehensive amendment of the EEG – EEG 2012 – in order to further slow down PV market growth and encourage the integration of PV into the electricity market. It came into force on January 1, 2012. First, it introduced a 52 GW PV threshold. Crossing this would require further policy change. In order to reflect the market conditions the amendment also brought further reductions of PV feed-in rates, but on the basis of existing degression rates with a mid-year adjustment, as in 2011. Moreover, the amendment introduced a new payment option for renewable energy producers (not only from PV systems) to sell power directly into the wholesale electricity spot market and not to the distribution system, the so-called market integration model (*Marktprämien-Modell*). This option should have additionally provided incentives for a market-oriented energy generation from renewable energy technologies in line with demand (Energy Experten, 2012). The renewable energy producers should since then decide, on a monthly basis, whether they would participate in the FIT system or sell their electricity directly to the spot market and receive the so-called "market premium" (*Marktprämie*), which is an additional payment to the electricity market price.

The amount of the market premium is calculated on a monthly basis as a difference between the feed-in rate available in a given month and a "reference price", which is the difference between the average spot-market price for the previous month and the management premium (DB Climate Change Advisors, 2012, p.4). The aim of the management premium is to compensate for the additional costs of participating in the wholesale market for the renewable energy producers – costs that could result for instance from misleading prognoses (Energy Experten, 2012).

Since the management premium declines over time, which leads to a smaller market premium, it is an incentive for early participation in the electricity wholesale market and for degression of the costs of this participation (DB Climate Change Advisors, 2012, p. 4). It was believed that the market integration model would lead to a decline in the EEG surcharge costs as well as to the growth of renewable energy capacity (see, for instance, Energy Experten, 2012). However, it is also claimed that it has done the opposite (see section 4 of this chapter).

The EEG 2012 also introduced changes to the *Grünstromprivileg* – since 2012 the exemption has amounted to 2 ct/kWh, but the maximal amount cannot be higher than the EEG-surcharge. Moreover, the exemption given to the energy-intensive industry has been further expanded, so that in 2013 2,000 companies (as opposed to 700 in 2012) have been exempted.

2012 PV amendment

In June 2012, one year after the EEG amendment, the government decided to introduce further reductions to the PV feed-in rates. This was the outcome of very long political discussions about the future of the German PV support regime. Finally, a compromise was found in the mediation committee of the Bundestag and Bundesrat (*Vermittlungsausschuss*) and the so-called PV amendment was adopted.

First, all feed-in rates have been reduced by 15 percent. Systems smaller than 10 kW received the highest feed-in rate of 19.5 ct/kWh, whereas free-standing systems received the lowest rate of 13.5 ct/kWh. From May to October 2012 the feed-in rates were reduced by 1 percent a month (BMU, 2012b). Next, the monthly degression depended on the capacity added in the previous 12 months and adjusted every three months (see the table: 'Vergütungssätze neu – nach der PV-Novelle' and 'Zusammenfassung der wichtigsten Änderungen durch die PV-Novelle' in: BMU, 2012b).

Depending on whether the so-called capacity corridor of 2,500–3,500 MW would be exceeded or not reached, the degression would be increased or even abandoned (BMU, 2012b). The capacity corridor will remain at 2,500–3,500 MW until Germany reaches a total installed capacity of 52 GW (DB Climate Change Advisors, 2012, p. 5). When this cap has been reached, new installations will receive no further feed-in rates (see: 'Zusammenfassung der wichtigsten Änderungen durch die PV-Novelle' in: BMU, 2012b). However, priority grid access should be granted later on for the new installations (BMU, 2012b).

The PV amendment also brought some relevant changes to the market integration model for PV. The new building-mounted installations, as well as installations mounted on noise barriers, with capacity > 10 kW and < 1 MW, going on-grid in 2012 and 2013 have been allowed to receive feed-in rates for no more than 90 percent of the electricity that they generate in a calendar year. For the remaining 10 percent of electricity the generator receives neither the feed-in rate nor the market premium. Moreover, the new law 'requires all PV systems to have curtailment capability in order to shut off during periods of potential grid instability and reduce the need to expand the grid to absorb output'. Half the costs of the curtailment capability should be paid by consumers, the other half by generators, who receive 95 percent of the feed-in rate for the curtailed energy (DB Climate Change Advisors, 2012, p. 21).

Critical points and potential implications for the future

Over the past decade the EEG has become ever longer, ever more detailed and complicated. Its key support mechanism, the FIT scheme, has become more difficult to estimate, offering less transparency, less longevity and less certainty to investors, as DB Climate Change Advisors (2011, 2012) stated. The reason is that over the last couple of years the feed-in rates and the degression schemes have been changed spontaneously many times as ad hoc reactions to PV market development and declines in PV module prices, and sometimes have even been backdated. The rapid PV price declines have been accelerated to a great extent by the emergence of competitors from China that have risen to be global players and have been flooding the world with cheap modules (Schultz, 2011). In 2011, prices declined by 30 to 40 percent – far faster than the production costs. According to estimates by the Federal Environment Ministry, Asian suppliers have sold their modules even below production costs to gain market share. And they have been successful, as Schultz shows: in 2004 the Chinese manufacturers' share in global PV sale accounted for 7 percent, in 2010 it was already 45 percent and, currently, the Chinese manufacturers have an estimated market share in Germany of 50 percent. As a result of the Chinese competition and the changes in domestic PV policy, sales and revenues have dropped for many German solar companies (for instance First Solar, Solarworld), and they have had to revise their forecasts for the upcoming years (Schultz, 2011). However, in the long term, as Fraunhofer ISE estimates, the declining production costs of PV modules on the one hand and increasing freight costs and transport duration for modules from Asia on the other hand, will steadily improve the competitive position of module production in Germany (Fraunhofer ISE, 2013, p. 28).

Also, the recent financing options for the market integration of renewable energy have been broadly criticized by the opposition parties in the parliament and by experts as well as renewable energy associations (see, for instance, Bundestag, 2011; EUWID Neue Energien, 2012). The market premium system seems to provide more risk and uncertainty to investors than the FIT scheme because the latter is a fixed-price payment in contrast to the former, where the variable premium payments depend on the average market price in the previous month as well as on the feed-in rate. However, this risk is somewhat reduced by the management premium, 'which partially decouples the market premium from the calculation of the wholesale market price', and the fact that producers can switch back and forth between the fixed and premium price payments (DB Climate Change Advisors, 2012,

p. 7). Moreover, criticism has been voiced that the market premium will neither contribute to the market integration of renewable energy nor to the development of supply management solutions for fluctuating renewable energies, such as energy storage. This would only lead to high profits for those who will take part in the electricity market anyway, and would cause additional costs of €1–2 million (Eurosolar, 2012). Therefore, in the opinion of Eurosolar the better instrument for enhancing the integration of renewable energy into the electricity market is the *Grünstromprivileg*. This was however, reduced by the government. Another instrument proposed by this European association is the so-called 'storage bonus' (*Speicherbonus*) within the EEG for the energy storage and virtual power plants. The point here is to reduce the necessity of grid development by making a faster transition towards a decentralized electricity system based on renewable energy (Eurosolar, 2012).

One very controversial issue is the cost of the EEG, especially with respect to the support of PV. The continuous reductions of the feed-in rates and the adjustments to the degression scheme for PV intended, among other things, to reduce the electricity costs for society, which pays for the EEG-surcharge. Yet, the overall electricity price has been continuously increasing for the last ten years. However, the reason for this is not the development of renewable energy and the increasing costs of the EEG surcharge. Rather, this is first and foremost because of the increasing grid use costs, costs of the conventionally generated electricity, and different taxes (see, for instance, BMU, 2009). Another reason for the rise in the electricity price are the concessions made to energy-intensive industry. The big energy-intensive companies are exempted from the EEG surcharge and, in 2013, even more companies were exempted than in 2012. In addition, the same companies have also been exempted from paying grid use costs. They also profit from the decreasing electricity prices on the stock market stemming from the merit-order effect. This increases the electricity costs for private households and medium-sized enterprises (see more in: DB Climate Change Advisors, 2012, pp. 24–25; Forum Ökologisch-Soziale Marktwirtschaft, 2012; Hummel, 2012; klima-allianz deutschland, 2012; Rosenkranz, 2012).

The concessions given to energy-intensive companies provide an example of the influence that different industrial actors wield over German renewable energy policy, not only in the electricity sector. The companies of the conventional energy sector have played a particular role in the process of the formulation and implementation of this policy. The main conflict between these actors and those representing the renewable energy industry arose over the way and extent to which renewable energy was being supported (Hirschl, 2008, p. 578). Although there is some common ground between these actors – mainly with respect to large renewable energy plants such as offshore wind or large hydro power plants – in general they constitute rival advocacy coalitions and are usually in opposition to each other. According to Hirschl, who analyzed the renewable electricity policy cycle in Germany, the main reason for this conflict has been socio-technological. For decades conventional power companies have focused on an infrastructure of central power plants, in contrast to what is the case with this largely new emerging industry with new players that have been supported by the positive social attitude to decentralized technologies (Hirschl, 2008, pp. 578–9). This conflict might explain some of the rapid changes in policy support for PV that has taken place, especially during the last couple of years. Another explanation for these changes might be the change in the coalition government in Germany: after seven years in power, the coalition of the SPD and the Greens (1998–2005) – which was the coalition that created and adopted the EEG in the first place – was replaced by a CDU/CSU–SPD (2005–9) coalition and next the coalition of the CDU/CSU and the FDP (2009–13). Both the CDU/CSU and the FDP are supportive of the big, conventional energy industry as well as of energy-intensive companies. SPD decided in 1986 to phase out nuclear power; it remained, however, the political voice of the coal industry.

The first section of this chapter presented an overview of the current discussion in Germany about the road to grid parity of PV. Although achieved in theory, PV retail grid parity differs from case to case, determined by a broad range of factors. Thus, for practical purposes retail grid parity has arrived in different parts of Germany at different times. It 'will likely require the development of new policy and regulatory frameworks to address such issues as revenue loss for utilities from behind-the-meter consumption and the emergence of new business models, such as the third-party PPA[3] model that has helped drive PV markets in the US' (DB Climate Change Advisors, 2012, p. 23) as well as 'changes to retail rate structure, etc., that would serve to push the parity point further into the future' (DB Climate Change Advisors, 2012, p. 23) by preserving elements of the FIT scheme. The reason for the latter is firstly the greater attractiveness of long-term contracts than on-site consumption; secondly, the inability of many producers to consume power on-site; and, thirdly, the lower costs for electricity consumers if generators were obliged to sell power at the feed-in rate at below retail rates (DB Climate Change Advisors, 2012, p. 24). However, the greater challenge for the development of future renewable energy policies in Germany is the fact that renewable energy is suppressing the wholesale electricity price because of the merit-order effect, which regularly pushes wholesale grid parity further out. For this reason we should consider whether or not we need to find another benchmark for renewable energy than spot-market electricity prices, such as for instance the cost of building new conventional generators (DB Climate Change Advisors, 2012, p. 24).

The rapid development of renewable energy, especially those technologies, such as PV, that deliver a fluctuating electricity supply also causes problems for grid stability and energy security in Germany. Several solutions that could provide stable electricity supply in periods of weaker or too-strong generation from the sun (or the wind) are, however, being discussed. The main proposals are the capacity markets and strategic reserve with electricity-storage technologies and load management strategies (see, for instance, Nailis et al., 2011; Trittin et al., 2012; Umweltbundesamt, 2012). Currently, energy storage technologies and load management strategies are being technically developed.

Conclusions

Germany has become a world leader in PV development and promotion. The rapid PV development has been particularly notable after the introduction of the EEG in 2000, which has been amended several times since then. The key element of this law is the renewable energy promotion mechanism based on the FIT scheme. It consists of many design features creating investment security for PV generators: a purchase obligation for renewable electricity, cost-based tariff levels, priority grid access, and tariff degression. During the last few years the PV market has developed more rapidly, and the costs of PV panels have dropped faster than expected, approaching grid parity and, in the opinion of German decision makers, causing an increase in electricity costs for consumers. Therefore, the German government has decided to introduce several mechanisms to slow down PV market growth and encourage the market integration of PV. These consist of feed-in rate reductions, a feed-in rate degression scheme, production limits and a 52 GW threshold. However, in recent years the feed-in rates and the degression scheme have been spontaneously revised many times and even backdated. In addition, the EEG has become continuously longer, more detailed and complicated. As a result, the support mechanism for PV has become more difficult to estimate, offering less transparency, longevity, and certainty to investors. Nevertheless, the main goal of the German support framework, namely to drive PV costs down its learning curve in order to encourage PV market integration, has been achieved, and the recent FIT amendment offers tariffs which are below retail electricity prices. This development has, however, not yet driven widespread on-site power consumption. Also, due to the merit-order effect renewable energy is delaying wholesale grid parity. These issues, as well as the increasing amount of fluctuating electricity supply from PV, pose great challenges for German decision-makers and need to be addressed in the future by new German policy frameworks.

Notes

1. The tariff payment in the year 2000 amounted to more than 50 ct/kWh as opposed to water energy (7.67 ct/kWh), biomass (between 8.70 and 10.23 ct/kWh),

geothermal energy (between 7.16 and 8.95 ct/kWh), and wind energy (between 6.19 and 9.10 ct/kWh) (EEG, 2000, pp. 2–3).

2. The merit-order effect is a consequence of renewable electricity fed into the system replacing electricity produced by plants with higher marginal electricity costs. This, in turn, lowers wholesale electricity prices.
3. PPA – Power Purchase Agreement: according to the United States Environmental Protection Agency it is a financial arrangement in which a third-party developer owns, operates, and maintains the PV system, and a host customer agrees to site the system on its roof or elsewhere on its property and purchases the system's electricity output from the solar services provider for a predetermined period (Environmental Protection Agency, 2012).

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14

Vested Interests, Energy Policy and Renewables in Japan, China, Norway and Denmark

Espen Moe

Introduction

This book looks at many different aspects of renewable energy and renewable energy policy. In the rhetoric of almost every country, energy issues, including the installation and phasing-in of renewable energy, have a high priority. Both for peak oil and climate reasons, credible alternatives to fossil fuels ought to have a bright future. We pretty much know that an energy transition, away from fossil fuels, must eventually take place. And still, despite a certain amount of policy convergence, if we look at the enthusiasm with which various countries have implemented renewable policies, we see major differences. This chapter suggests one answer as to why.

The answer is sought in an analysis of the renewable policies of Japan, China, Norway and Denmark – four very different countries. Two are major industrial powers. Japan is small, densely populated, with almost no natural resources of its own, but wealthy after decades of successful industrialization. China is a geographical giant, abundant in a number of natural resources, still relatively poor, but with growth rates so tremendous and persistent that satisfying its future energy demand will be a major challenge. The other two are small, but technologically sophisticated economies, one of which (Denmark) arguably hosts the world's foremost wind power company (Vestas) and the other (Norway) being a major petroleum exporter with almost of all its electricity derived from hydropower. These differences go together with differences to their renewable energy policies. Thus, the suggestion made here, is that there is a common theme, according to which the renewable policies of these countries can be analyzed. More specifically, I suggest that we need to look at the vested interest structures of these countries in order to find out why they have fared so differently. While there are obviously other explanations as well, it is vital not to overlook the importance of politics. Hence, this chapter tries to say something about how politics, primarily in the guise of vested-interest politics, has influenced renewable energy policy.

Vested interests have been important with respect to the prospects of renewables in all four countries. That renewables have struggled in Japan, which imports virtually all of its energy, is in itself interesting enough. If unsolved energy problems were the main driver behind renewable energy expansion, Japan should have been a frontrunner, but this is only partially true. In solar power it used to be, and in wind power it never was, although the tragedy of Fukushima may be forcing an energy policy rethink. Instead, showing how solar power and wind power are situated very differently inside the Japanese vested-interest structure goes a long way towards explaining the differences between the two. China seems easier to explain. It has major energy needs, as well as considerable wind and solar resources. Thus, its rapid expansion in renewables is as expected. However, the Chinese case also lends strength to the vested interest approach: In Japan, wind challenges the existing vested-interest structure far more than does solar. In China, wind power is the preferred solution, even if here as well the vested-interest structure often prevents the seamless integration of wind. Despite impressive growth figures, there are a number of hurdles that need to be negotiated. Future growth will seriously depend on how China deals with what may become very serious vested-interest problems. In Norway, vested interest structures are crucial to explaining why renewables have problems competing with the petroleum industry. However, it is also important to note that prior to the emergence of a Norwegian petro-industrial complex, the country already had something akin to a hydro-industrial complex, which means that in terms of energy production, Norway has had little need for new renewables like solar and wind. Contrast this with Denmark, where wind power led a sheltered existence for a number of years and was successful in the absence of strong rival vested interests, and where the success of wind power and of Vestas meant that in Denmark wind power is itself a powerful vested interest. This abruptly ended with a change in government, and so the years between 2003 and 2008 represented a complete standstill in terms of Danish renewable progress. Since 2008, the political landscape has again changed, and renewable energy policy has changed with it, at least in part because of the influence of the Danish wind-power industry. This does also show that no matter how strong different vested interests are, political change sometimes trumps everything else.

On the whole, however, I do suggest that vested-interest structures are vital to explaining the different outcomes between these countries, as well as the importance of the institutions and politics through which the vested interests are typically transmitted. I also suggest that when it comes to explaining major transitions, like energy transitions, it is crucial to look at vested-interest structures and the extent to which these enable or hamper change. The phasing-in of renewable energy is only one in a series of such (potential) energy transitions.

Some theoretical remarks

An obvious starting point for an analysis of energy policy is the assumption that the ambitiousness of a country's renewable energy policies mirrors the seriousness of its energy problems. Countries with major unresolved energy problems and/or abundant renewable energy resources should have more ambitious renewable energy policies.[1] Here I am instead trying to explain why some countries have mediocre renewable energy policies despite either unresolved energy problems or abundant renewable resources, as well as why some countries have strong preferences for one type of renewable energy and not for others.

The theoretical background for the chapter is one of structural economic change, or of economic transitions and transformations. With no remaining cheap or abundant sources of energy (with the possible exception of shale gas), the promotion of renewable energy could easily be thought of as self-evident. At some stage a transition away from fossil fuels must simply take place, for climate reasons and because we will eventually run out of fossil fuels. And since Fukushima, the notion that nuclear can provide a way out of our woes has looked distinctly more dubious, among other things triggering an *Energiewende* (or in English an energy transformation) in Germany.

At the same time, there are obvious reasons why renewables have not made a big impact yet. Structural change is a thorny and tenuous process. It always implies both winners and losers. It brings the rise of some industrial activities, but the demise of others. And so, structural change is often fought tooth-and-nail by vested interest groups (Mokyr, 1990). The rising industries will typically not yet have powerful interests backing them; they have not yet organized to form special-interest organizations and do not have the backing of powerful parliamentary representatives, and so forth. Against this, the stagnating industries have often been there for decades. They have had ample time to organize, have access to political networks, and have succeeded in forming institutional structures beneficial to their needs. Politically, economically and institutionally, they have all the advantages, and the new and upcoming industries have all the disadvantages. Thus, even if the time is otherwise ripe, structural change does not just happen by itself in any given country.

In any political economy there are a number of vested interests seeking to preserve the status quo (Mokyr, 1990). Energy interests are usually among the most powerful of these. Unruh (2000) once coined the term techno-institutional complexes (TIC), or large technological systems embedded through feedback loops between technological infrastructure and institutions. Once locked in, they are not easily replaced. Today's oil, coal and energy companies are the biggest industrial giants on the planet, part of a TIC that perpetuates a fossil fuel-based infrastructure that is exacerbated by government subsidies and institutions, resulting in 'carbon lock-in.' It typically takes strong political action to displace a TIC and implement a new energy structure. And, so, altering the energy structure at the expense of the already-existing energy actors is likely to meet with resistance.

Theoretically, this chapter rests on Joseph Schumpeter (1942, 1983) and Mancur Olson (1982). It blends Schumpeter's evolutionary economics and 'waves of creative destruction' with Olson's focus on vested interests. Schumpeterian economics emphasizes the importance of structural change. There is an inevitability about the rise of industries and the demise of others. Industries rise because they provide society with new and more efficient ways of doing things, providing tangible and long-lasting benefits. And they fall because what was once technologically revolutionary becomes commonplace and obsolescent as society invents other means and technologies by which to solve its problems and challenges. Hence, in the Schumpeterian world, there is a steady rise and fall of industries, linked to technological progress, often grouped in waves of innovation, waves of stagnation, 'waves of creative destruction.'

From Olson (1982) comes the observation that, in the long term, rigidities silt up in the economy. Without major shake-ups, any economy gradually becomes ever more inefficient. This has to do with vested interests wresting power away from elected policy-makers, in extreme cases ending up with so much power that politics is reduced to propagating the interests of the most powerful vested interest groups.

Historically, waves of structural change have occurred, with 50–60 year intervals (e.g., Bairoch, 1982; Cameron and Neal, 2003; Gilpin; 1981; Modelski and Thompson, 1996; Moe, 2007; Rostow, 1978). At least since the Industrial Revolution, industrial waves of core industries rising and old industries stagnating have provided the dynamic of the world economy: Cotton textiles during the early Industrial Revolution, then iron; chemicals during the so-called Second Industrial Revolution, then consumer durables in the early 20th century, followed by growth from information and communication technologies in the late 20th century onwards. While there may be disagreement on the exact periods and industries, there is ever-greater consensus on the importance of structural change, on vested interests, and on creative destruction, as well as on the institutional mechanisms behind these changes (see, for example, Acemoglu and Robinson, 2012; Ferguson, 2012; Mokyr, 1990; North et al., 2009).

Industrial waves have largely coincided with major energy transitions (Ayres, 2006; Fouquet, 2008; Freeman and Louçã, 2001). The discovery and exploitation of a new and abundant resource that is rapidly becoming far cheaper or vastly more powerful, has occurred in symbiosis with industrial change, structural change within industry and energy fuelling each other. We witnessed the end to animate sources of energy driving the economy with the Industrial Revolution. This shift reached its completion with coal, steam and iron. The Second Industrial Revolution depended on breakthroughs in electricity production. And the automobile industry would not have had such an impact if not for the exploitation of oil.

Now, oil – the once cheap and abundant source of energy – is no longer cheap, and not as abundant (with shale-gas a potential game-changer). Furthermore, climate concerns provide us with additional incentive to pursue energy paths that involve the exploitation of renewable sources of energy. Thus, in this chapter, I look at how vested-interest structures are influencing and affecting the ways in which this is possible in Japan, China, Norway and Denmark.[2]

Japan: solar on the inside, wind on the outside, Fukushima as a turning point?

Vested interests are key to understanding Japanese energy policy. They consist of an iron triangle encompassing the bureaucracy, the Liberal Democratic Party (LDP) and business interests, in particular those of the electric utility companies. Insiders are systematically protected, at the expense of outsiders. Politics is opaque, with government weak and the bureaucracy – in particular the Ministry of Finance (MOF), the Ministry of Economy, Trade and Industry (METI) and the Ministry of Foreign Affairs (MoFA) – exceptionally strong, politicized, and with close business ties (Emmott, 2009; Katz, 2003; Moe, 2012; Schlesinger, 1999). The ties mean that government ministries treat their main industrial interests as 'clients,' seeking to further the client's interest. For METI, among the foremost clients are the electrical utility companies. The low civil service retirement age (55 years) results in prominent civil servants 'retiring' to top jobs in those companies they dealt with as civil servants,[3] creating a harmony of interest and, to METI, giving strong preference to the utilities in matters of energy policy. The relationship between the utilities and the LDP has traditionally also been tight (DeWit and Tani, 2008; Emmott, 2009; Luta, 2010).

The bureaucracy and the LDP have always preferred nuclear. In 2005, Japanese nuclear R&D amounted to twice that of the other 25 International Energy Agency (IEA) countries combined. Since the 1960s, Japan has been extremely committed to fast-breeder reactors.[4] Of the total Japanese energy subsidies (1970–2007) nuclear received ¥9.7 trillion ($120 billion) and renewables ¥1.7 trillion ($20 billion) (DeWit and Iida, 2011; Iida and DeWit, 2009; Oshima, 2010; Schilling and Esmundo, 2009). According to METI's 2010 Basic Energy Plan (*AEEC*, 2010), 14 new nuclear plants were to be built by 2030, increasing the share of the electricity supply production from 30 to 50 percent. And the Denjiren (Federation of Electric Power Companies of Japan) welcomed the Democratic Party of Japan (DPJ) administration by stating that nuclear is the key to Japan's energy future, and that the DPJ must respect the continuity of important national policies (*FEPC*, 2009). Japan is, however, one of the world's most earthquake-prone states, with related accidents, scandals and lucky escapes.[5] This has led to rampant NIMBYism and huge compensation costs so as to pay off various actors before nuclear can be installed in anyone's neighborhood.[6] Hence, electricity remains expensive, but as compensation costs are not part of official estimates, the official cost of nuclear electricity is artificially low. Most likely, wind would be competitive if compensation costs were included (Iida in *Japan Times*, 2007).

The DPJ came to power in September 2009, explicitly vowing to combat this iron triangle. Since 2003, the main Japanese renewable policy instrument had been the Renewable Portfolio Standard, obligating the utility companies to provide a certain share of their electricity from renewables, but at a lowly 1.63 percent of electricity output by 2014, they had no problem fulfilling this (IEA, 2008). In 1999, a Diet initiative to introduce a feed-in tariff (FIT) had been successfully fought by METI and the utilities. This led METI to become very territorial about energy policy, as it did not enjoy outside rivals for power (the Diet) wresting away energy policy-making (Iida, 2010; Maruyama et al., 2007). As a pre-emptive measure to the DPJ's election victory, METI launched its own FIT. Quoting Iida and DeWit (2009), it was a 'half-baked scheme cooked up by METI's internal politics and client-list of vested interests,' and a proposal constructed by people strongly against any FIT. The DPJ plan was more comprehensive. Instead, the METI scheme gave almost exclusive preference to solar. In October 2009, the Denjiren stated that it would do anything to restrict the FIT, meaning no smart grids and no renewables beyond solar (DeWit, 2009). Following Fukushima, a comprehensive FIT has been introduced, but until then, energy policy-making was characterized by gridlock and by the utilities having their way with METI.

Renewables

In terms of renewables, METI has always preferred solar power. The 1970s oil crises led to the realization that Japan was exceedingly vulnerable in terms of energy security, relying heavily on Middle Eastern oil. One response was to develop alternative sources of energy, solar being one of these. The funding of solar was also an attempt at linking industrial and energy policies, drawing on traditional Japanese strengths in the manufacturing of high-technology equipment. To METI, the success of solar gradually became a matter of prestige, synonymous with the success of METI itself. While solar has challenged the existing vested-interest structure to a far lesser extent than wind, and suffered far less opposition from the utilities, it would hardly have risen without bureaucratic support. Solar is a minor player compared to the utilities. But compared to wind, it enjoys a kind of partial insider status. It has worked within rather than against the existing vested-interest structure, and it has enjoyed consistent support inside METI (Bradford, 2006; DeWit and Tani, 2008; Kimura and Suzuki, 2006; Schreurs, 2002).

Solar photovoltaic (PV) has benefited from government R&D going back to the 1974 'Sunshine Project' of the Ministry of International Trade and Industry (MITI, in 2001 superseded by METI). The budget increased considerably after the 1979 oil shock. MITI lost faith with solar thermal, which had been the program's mainstay, but wanted to retain the budget, which had by then increased by more than 200 percent, and thus switched from thermal to PV. A new agency, the New Energy and Industrial Technology Development Organization (NEDO), was established in 1980, and a legal framework for fostering renewables was hammered out. In parallel with the Sunshine Project, several companies contributed R&D of their own, although the government's commitment was most likely a more important stimulant, as no commercial profits were yet to be had, and so Sharp, Sanyo and Kyocera went on to become the core of the Japanese solar panel industry, organizing to form the Japan Photovoltaic Energy Association (JPEA) (Broadbent, 2002; DeWit and Tani, 2008; IEA, 2008; Kimura and Suzuki, 2006).

Lobbying helped remove regulatory barriers. Rooftop panels used to be classified as 'power generation facilities,' requiring an electrical chief engineer for each and every panel installed, but momentum was created as newspaper articles and television shows addressed the issues. Grid connection was another problem, as the utilities insisted that solar was unstable and refused to contribute to a market that they considered marginal. It took a four-year (1986–90) NEDO demonstration project to persuade them of the stability of PV, along with gently impressing upon them that they would be forced to give in, anyway (Kimura and Suzuki, 2006).

The 1995 Seventy Thousand Roofs program established a 50 percent subsidy on the cost of residential PV systems (Bradford, 2006; Kimura and Suzuki, 2006). The program expired in 2005. METI had assured MOF that the subsidy would only run until self-sustained growth was achieved, which would coincide with a swing in favor of market-based policies initiated by Prime Minister Junichirou Koizumi (2001–6). In 2005, three of the world's five biggest solar-panel manufacturers (Sharp, Sanyo, Kyocera) were Japanese (Broadbent, 2006; IEA, 2008; Kimura and Suzuki, 2006; DeWit and Tani, 2008). Since then, Japan has lost its number-one position. At 7 GW, Japan no longer has the world's largest installed capacity of PV – Germany has more than 32 GW and Italy 16 GW, and in 2012 China passed Japan as well – and Sharp in 2007 lost its position as the world's largest PV producer. Japan now controls only 5 percent of the market, down from more than 50 percent in 2004 (EPIA, 2013; Roney, 2010). A subsidy was reintroduced in January 2009, and a FIT in November 2009. In the wake of the 2011 Fukushima accident, a comprehensive FIT was introduced, and NEDO has upgraded its 2020 target for PV installed capacity from 14 GW to 28 GW. Thus, the Japanese market is bound to grow rapidly, possibly outpacing Germany and becoming the world's second-largest in terms of annual installations, behind only China (DeWit, 2012c; EPIA, 2013).

The preference for solar was never for cost-effectiveness reasons. Wind always was cheaper (METI, 2010). But PV has also been a commercial strategy and an export strategy, whereas wind was only about power supply. Still, it took 20 years for commercialization in PV. By 1993, cumulative government investments had reached ¥600 billion ($7.5 billion), with almost no commercialization (Bradford, 2006; Kimura and Suzuki, 2006). To prevent the failure of a program that had been heavily funded, funding was scaled up instead of down. The subsequent success of PV, as well as the urge for MITI/METI to keep justifying its existence by pointing to industrial success stories of its own creation, made it vital for them to ensure beneficial terms for PV. METI considers PV a success, and NEDO's pride in Japan as the world's number one in solar panels was palpable (see for instance NEDOBOOKS, 2007).

The relative success of solar shows how much easier it is to succeed for an industry that is able to work within existing industrial and institutional structures. The success of solar PV was accomplished relatively without friction. At critical junctures the nascent industry was supported. First, MITI asked for a big budget, assuming that a big project would more easily become a permanent budget feature. At the next juncture MITI shielded the budget and received a huge increase because of the 1979 oil shock. When the utilities were reluctant to let solar onto the grid, NEDO's four-year pilot project forced them to give in. When focus was cast on the lack of technologies brought to the market, MITI used the amount of money spent to argue that deployment should be funded too. Up until the Koizumi era, solar had major players fighting for it at the expense of existing actors in the Japanese energy-industrial complex.

In comparison, wind power has been the ultimate outsider. No major interests speak on behalf of wind, and while wind turbines ought to be industrially promising, few industries see it as a natural extension of existing activities. Granted, wind power capacity increased reasonably briskly, from 136 MW in 2000 to 2588 MW in 2012. Regulatory change in 2007 ground installation to a halt for a year, and then came the financial crisis. Hence, the 2010 3 GW target was long unreachable. In 2011 Japan installed only 87 MW, compared to 13 GW in both the United States and China. Even after Fukushima, capacity has been at a standstill and remains at a little over 2.5 GW – more than Norway, but less than Denmark, and far less than Germany at 31 GW or China at 75 GW (Engler, 2008; Maruyama et al., 2007; WWEA, 2013).

Among the main reasons for wind's failure is that it challenges the existing framework far more than does solar: MITI always saw greater potential for commercialization of solar, which fit into their preference for high-tech exports. Solar policy was energy *and* industrial policy, while wind was only energy. But, also, PV and wind supply power differently. PV is installed on rooftops. Since houses are grid-connected, the solar panel is automatically connected, whereas a wind turbine is set up away from the grid, prompting the question of who should pay for the connection cost. Because electricity transmission and generation have not been unbundled, the utility companies can shut wind power out from the grid, which they cannot with rooftop solar. Also, most wind turbines are located in the countryside, where the grid is often weak. However, what is probably most important is priority access to the grid. Unlike China and Denmark, Japanese wind power does not have this (although the most recent energy law will make it much harder for the utilities to deny access). Without access, wind power cannot grow. In short, the degree of structural change required is far greater than for solar.

The main problem is that Japan's ten electric utilities – each with a regional monopoly – strongly oppose this structural change, and they usually get their way with METI. For the utilities to let wind power into the grid is like acquiescing to a process of liberalizing the entire electricity sector, which they have fought tooth-and-nail for 15 years. Wind power is produced by independent power generators. The utilities buying electricity from wind power generators is like making a contribution to the enemy. And so, according to Iida (in Engler, 2008), they 'act as regional monopolies, functional monopolies, and political monopolies. They are rule makers, and they make an effort to exclude wind power from their grid.'

Wind power has met with a number of objections from the utilities. One is that Japanese weather conditions are particularly difficult, with choppy winds and seasonal typhoons. For this reason in the 1990s even NEDO concluded that large-scale wind power was unfeasible in Japan. The primary objection of the utilities is, however, the variability of the power source, making the grid unstable. Also, the Japanese grid is somewhat peculiar. In a large, integrated European-wide grid, temporal and spatial power fluctuations even themselves out. But Japan, with a population less than a third of the EU, is not connected to any foreign grid from which it may draw. Even worse, it is divided into ten regional monopolies with only weak inter-grid connections and not even the same nationwide frequency. Southwestern Japan runs on 60Hz, Northeastern Japan on 50Hz. This makes the vulnerability and reliability argument more credible than elsewhere. It also means that major wind power expansion requires greater infrastructural investment than would solar. Still, there is a sense that the utilities overplay this argument. The genuine reserve capacity may be less critical than the utilities admit to, and the grids probably better connected than the utilities claim. Providing renewables with priority access should be fairly unproblematic.

Fukushima

For years, Japanese energy policy was gridlocked. With the Fukushima disaster, a shock big enough to affect the entire political system occurred. It is not clear that change will result, but change is at least now a possibility. The immediate effect was for 10 GW of generating capacity, or more than 20 percent of the nuclear generating capacity (roughly 49 GW), to go offline. At the time of writing, all of Japan's 54 nuclear reactors are down, and the future of Japanese nuclear is very much in the balance. Rolling blackouts have been avoided, but electricity consumption in the summer of 2011 dropped by a full 9 percent compared to the previous year (DeWit and Kaneko, 2011; *Japan Times*, 2011b).

External shocks can be windows of opportunity. Since Fukushima, Japanese citizens have turned their stable support for nuclear into a stable majority opposing it. And while it is too early to know what the outcome will be, energy policy is subject to a serious rethink. In 2011, former PM Naoto Kan declared that by 2020 renewables should account for 20 percent of electricity production, and he made the passing of a general FIT a condition for his resignation as PM (*asahi.com*, 2011; *Bloomberg*, 2011; DeWit and Kaneko, 2011; *Japan Times*, 2011c; Midford, 2014).[7] His successor, Yoshihiko Noda, seemed more favorably disposed towards nuclear, among other things delaying the nuclear phase-out date of the DPJ from 2030 to 'by the end of the 2030s.'[8] Further, since this edict will be up for review every three years, it could conceivably be scrapped as early as 2015, as the LDP, which historically has been more pro-nuclear than the DPJ, is back in power. According to both the DPJ and the LDP, reactors should be phased back in if they can pass a series of required safety tests. Fukushima has, however, made the ease with which the utilities have gotten away with regulatory fraud, and the collusion between the utilities and the regulator, abundantly clear. METI has now downgraded nuclear from the core of energy policy to form only one of three pillars (energy efficiency and renewables being the other two) to the energy system. A 2012 METI report also recommended unbundling. While the electric utilities are dead against this, the current LDP administration seems to be in favor. Thus, a nationwide power-grid operator will be created by 2015 and the electricity retail market will be liberalized by 2016, whereas full unbundling of electricity transmission and distribution is set to happen between 2018 and 2020 (Ernst and Young, 2013a; *Japan Times*, 2013).

For renewables, one of the most promising developments post-Fukushima has been the passing of a comprehensive FIT, in effect since July 1, 2012.[9] At ¥37.8/kWh (initially ¥42/kWh) the rates for solar PV are three times German and Chinese rates, and the initial effect has been well beyond what was expected (DeWit, 2012c; Umbach, 2014). However, the price-setting committee is picked by the Diet. Thus, it is still hard to know whether or not rates will stand – and while the FIT has led to major optimism in the renewables industry, although more so for solar, it is still early days. But the Japanese PV market may now actually replace the U.S. market as the world's second largest. If projections of 6–9.4 GW of PV installations in 2013 turn out to be true, Japan in one single year, is essentially doubling its present capacity. Early signs for wind power are less promising, as a flurry of environmental barriers (some old, some new) are stalling development

(*Asia Times*, 2011b, 2011c; *Bloomberg*, 2011; DeWit, 2012a, 2012b; Ernst and Young, 2013a; Huenteler et al., 2012).

Since 2009, PV prices have fallen by as much as two thirds. However, this is less because of technological improvements than because of Chinese manufacturers flooding the market. The generous Japanese FIT might easily end up subsidizing Chinese imports rather than stimulating the domestic solar industry. Japanese PV will most likely benefit, at least short-term, but if the FIT is set so high that it triggers the same boom-and-bust cycles as in Europe, a Japanese bust will leave low-cost Chinese manufacturers standing while making life difficult for high-cost Japanese manufacturers with razor-thin profit margins (Asano, 2012; Ernst and Young, 2012; Huenteler et al., 2012).

While Fukushima will contribute to the more-rapid deployment of renewables, the short-run winner is LNG. This is the quick and dirty stop-gap solution, and the politically easy one. But an expensive one. In March 2012, Japan experienced its first trade deficit since 1980, as fuel imports soared (up from ¥17.4 trillion in 2010 to ¥21.8 trillion in 2011, and from 3.6 to 4.6 percent of GDP). LNG also lends itself to the continued dominance of the utilities. Thus, while the crisis could be a window of opportunity for renewables, and while public opposition to nuclear power makes the installation of new nuclear capacity politically impossible, energy policy-making power is still located within METI (and the Ministry of Finance), even if the influence of the Ministry of Environment has probably grown. Thus, METI is realistically still the fulcrum of energy policy, and is thus where attitudes toward nuclear and renewables must change (Adams, 2012; DeWit, 2012b; DeWit and Kaneko, 2011; Ernst and Young, 2012; Frei, 2012; Hayashi and Hughes, 2013; Scalise, 2010; Terashima, 2012).

China: no structural transformation, but fast-forward everywhere

China also has major unresolved energy issues, but certain renewables are fairly abundant. It has been a frontrunner in most kinds of renewable technology, with renewables (unlike in Japan) enjoying firm and consistent government support. In wind power it surpassed the United States in 2010 with 44 GW, and capacity now stands at 75 GW. PV used to exist as an export industry only, but for the past few years the domestic market has grown rapidly – to the extent that the goal for PV installations is now 50 GW for 2020 as opposed to only 9 GW for 2015. And China is by far the largest PV *producer* in the world, supplying nearly 60 percent of global demand, and hosting some of the largest companies (EPIA, 2013; Liu et al., 2011; Liu and Goldstein, 2013; REN21, 2013; WWEA, 2013). In the government rhetoric, both wind and solar are 'new strategic and emerging industries' singled out in the 12th Five-year Plan, promoted to replace the 'old pillar industries,' including coal and oil (Lewis, 2013). Renewables were not on the agenda until 2005, but following extensive reshaping of the regulatory framework, progress has been impressive, and it has been fast.

But maybe expansion in renewables should be taken more or less for granted. Economic growth remains strong, and energy demand keeps soaring.[10] Domestically, PV is growing from a very small base. Renewable electricity capacity as a share of total electricity capacity actually fell between 2005 and 2007, and coal, which still accounts for 70 percent of China's total primary energy supply (TPES), will remain dominant for decades (Andrews-Speed, 2012; Liu and Kokko, 2010; Wang et al., 2010; Zhang et al., 2010). Thus, it may be that we are not witnessing a Chinese energy *transition*. Little structural change has occurred. The pattern is first and foremost one of *more* energy.

Yet, the 11th Five-year Plan (2006–10) targeted a 20 percent reduction in energy intensity, and the final result was an impressive 19.06 percent. In the 12th Five-year Plan (2011–15) a 16 percent reduction target has been listed. The share of coal is supposed to drop to 62 percent of TPES, with the carbon intensity of the economy reduced by 40–45 percent by 2020, from a 2005 base (Guo et al., 2014; Price et al., 2011). Targets are fueled by several factors: One is the increasing realization that China will be hit harder than most by climate change. Second, while the domestic energy supply reliance is above 90 percent, it is unlikely to remain so unless China considerably ramps up its renewable energy production. And, third, there is a strong perception that renewables have major industrial growth potential (Lewis, 2013; Wang, 2010; Zhang et al., 2010).

While China is seemingly headed for the sky in terms of renewables, several challenges must be overcome. The underdeveloped grid network is one, the lack of coordination between different actors and branches of government and the opacity of the system another. While there have been only minor vested interest problems in China until now, these are challenges that will require tough decisions involving a number of powerful actors with overlapping areas of responsibility. In a future in which Chinese growth rates will arguably decrease, among the problems China will face, vested-interest problems are likely to be near the top.

Renewables

The first Chinese wind farm was connected to the grid in 1986 (Han et al., 2009; Xu et al., 2010; Zhang et al., 2010). By 2003, China was however nowhere close to fulfilling its 1 GW wind-power target. Capacity doubled between 2003 and 2005, but it was only with the 2005 Renewable Energy Law (REL) that wind power took off. Sinovel and Goldwind are now among the world's five biggest turbine manufacturers, and Goldwind has even tested off-shore turbines. The old and established state-owned enterprises (SOEs) have drawn upon a history of manufacturing in heavy machinery, electric power generation equipment and aeronautics. But Chinese wind power is still dependent on importing technologies and systems and suffers from a lack of qualified researchers and engineers. Turbines produced by smaller firms do not have the same technological, efficiency or utilization levels, and so, for the largest turbines, multinationals like Vestas, Gamesa, Suzlon and General Electric still dominate.[11] Domestic turbines are less reliable, and the wind-power industrial chain not as complete as in Europe. Quality control is an issue, and despite rapid technological progress, there is limited innovation in the industry. With rapid expansion has followed quality problems, even from the most prominent producers (Hu et al., 2013; Klagge et al., 2012; Wang et al., 2012). Wang et al. (2012) proclaim that the present innovative capacity is not enough to sustain the industry, and that a human-capital shortage is becoming ever more evident. However, growth has been extremely rapid and is expected to continue. Projected targets have been passed time and again, and at 75 GW as of the end of 2012, installed capacity has long surpassed the projected 2020 target of 30 GW, set in 2007, and the target is now ramped up to 200 GW by 2020 and 1000 GW by 2050. The first offshore farm was constructed in 2010, and thus far 24 offshore wind farms have been approved. With a projected potential of 550 GW, offshore wind may provide 50 percent of coastal electricity by 2030. So far, a target of 30 GW has been set for 2020 (Hong and Möller, 2011; Hu et al., 2013; Lewis, 2013; Ru et al., 2012; Xu et al., 2010; Zhang, 2011; Zhang et al., 2013; Zhao et al., 2012).

Solar PV never got the same privileged treatment as wind turbines. The growth of Chinese PV has been extremely rapid, but until recently the domestic market was very small. Instead, the German FIT provided a huge market for China, as 90 percent of Chinese solar cells were exported abroad (Liu and Goldstein, 2013; Zhang et al., 2012). By 2012, Chinese companies controlled almost 60 percent of the global PV market, up from only 3 percent in 2004. However, the financial crisis reduced European demand for PV and led to less generous European FITs, leading to an emphasis on developing a domestic Chinese market. Thus, installed capacity increased from 145 MW to 3 GW between 2008 and 2011 and leapt to 7 GW in 2012 (still low compared to Germany's 32 GW). Future targets have been shifted upwards to 50 GW by 2020. From non-existent only a few years ago, China now has the second-largest domestic PV market (probably soon to be the largest), with forecasts of annual installations of 10 GW by 2016, and hosts a PV industrial chain with more than 50 solar cell and 300 solar module companies as well as being abundant in quartz sand and silica. Still, public budgets for R&D in PV are minuscule compared to those of Germany and the United States, and far behind Japan as well (EPIA, 2013; Earth Policy Institute, 2013; Grau et al., 2012; Huo et al., 2012; Liu and Goldstein, 2013; Zhang, 2011; Zhao et al., 2011).

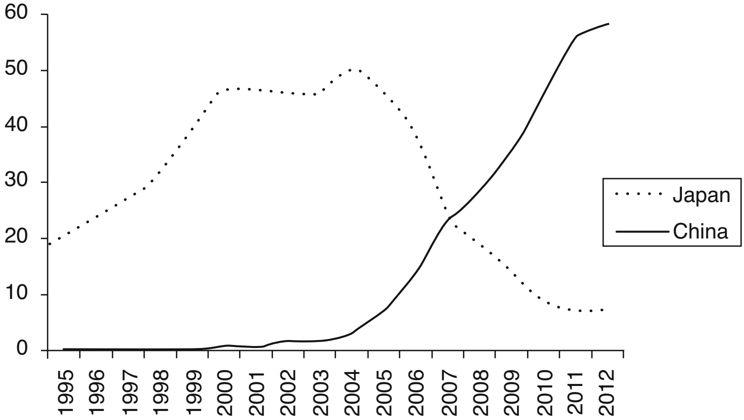

Figure 14.1 Solar PV market-shares, China versus Japan, 1995–2012 (percent)
Sources: Earth Policy Institute (2013) and Roney (2010).

The preference for wind over solar is primarily about technology. Technological entry barriers in PV (and modules) are far lower than in wind. The technologies are familiar, and production is labor- and energy-intensive rather than capital-intensive. Thus, international competitiveness was reached without much policy support. Prices for PV have dropped by 75 percent since 2008, mainly because of massive supply from Chinese manufacturers and a drop in demand from European countries. This has reduced the profitability of the industry, but as Chinese labor costs are low, Chinese manufacturers can supply solar cells at prices 20–30 percent below the competition (Zhang et al., 2012). Consequently, 9 of the top 15 PV manufacturers are Chinese. Still, these are not shielded against competitive pressures. Wafer-thin profit margins are hitting non-Chinese manufacturers harder, but the recent bankruptcy of Chinese giant, Suntech Power, shows that even the Chinese are not immune to the glut on the market that they themselves have created.[12]

Vested interests?

At present, vested interests seem insignificant. Yet, it is hard to gauge the actual strength of Chinese vested interests. The Chinese economy is still to a far greater extent than Western economies characterized by command and control and heavily populated by SOEs, which represent more than 80 percent of installed wind capacity. The state commissions wind-power projects, operates wind farms, and produces the manufacturing equipment through the SOEs (Liu and Kokko, 2010). Thus, the state keeps interacting with itself, and it is not easy to determine who the actors, and the potential vested interests, actually are, or how strong they are. One might conclude that because the state is so heavily involved, vested interests have been eliminated. This would be a fallacy.

First, this in many ways is also the name of the game in Japan. The Japanese bureaucracy has a number of policy divisions. METI is no neutral actor, and its relationship with select industries is close and protective. There is no obvious reason why an economy consisting of SOEs would have a substantively different relationship with a very opaquely institutionalized system. With a plethora of SOEs with lax budget restrictions, inefficiencies are more glaring, and the relationship with the state potentially more incestuous and even more based on personal relationships than elsewhere. The 2003 Wind Power Concession Program had the glaring weakness that, when concessions go to the lowest bidder, and SOEs have laxer budget restrictions than private firms, they can more readily underbid than can the competition. Thus, state-owned power companies received 97 percent of the concessions, but were often unable to fulfill them, as they did not have the financial resources to construct and operate them at the price of the bid, and subsequently seriously underinvested in the wind farms (Han et al., 2009; Liu and Kokko, 2010; Ru et al., 2012; Wang et al., 2010; Xu et al., 2010; Zhang et al., 2010, Zhang et al., 2011; Zhao et al., 2012). Evidence from other countries also suggests that opaque systems characterized by personal relationships constitute environments in which vested interests thrive, and where mobility, institutional flexibility and openness to change is replaced by an established order that shelters the actors on the inside of the system (Acemoglu and Robinson, 2012; Ferguson, 2012; North et al., 2009).

Second, the SOEs dominating wind are power companies relying primarily on thermal, oil and nuclear. They have branched out into wind because the state forces every power-generation company to have a certain amount of non-hydro renewable power (5 percent) in their energy portfolio (Liu and Kokko, 2010). Being part of a bigger company could mean that wind is sheltered from the vested interests that it is exposed to in Japan, but if the energy companies are taking on wind only because the state mandates it, and not as a business opportunity, this could lead to the neglect of wind and to the power companies only fulfilling the minimum requirement. On the provincial level, there is clear evidence of interest battles between thermal and renewables (Zhang et al., 2013; Zhao et al., 2013).

Third, while Chinese wind power installation figures are highly impressive, 20 to 30 percent of the capacity is not grid-connected. Add to this that the operating efficiency is low (less than half of that of the United States), and we should not paint a rosier picture than can be justified. In 2011, both the United States and China had 47 GW of *grid-connected* wind power. However, whereas the United States got 120 TWh from its 47 GW, China only managed 74 TWh (Schuman and Lin, 2012; Wang et al., 2010; Zhang et al., 2013). In Jilin Province in the Northeast, a wind-farm was located 300 kilometers from the nearest major city, and the closest 220kV line was 150 kilometers away. While much attention is given to state-of-the art large-scale turbines, poor integration between wind-farm and grid is the biggest obstacle to growth (Wang et al., 2012). The National Energy Administration (NEA) implemented regulations in 2011 to prevent wind-power curtailment, but that same year curtailment in the Northwest reached almost 35 percent, and overall curtailment rates are rising (Lewis, 2013; Schuman and Lin, 2012; Zhao et al., 2013). There is an awareness of these problems, but the political economy of Chinese renewables still leaves much to be desired.

Unlike in Japan, the 2005 REL specifies that renewable energy has priority access to the grid, and that the grid company bears any losses from problems connecting renewable energy to the grid. It obliges the grid companies to purchase wind power and the power companies to supply it, and this has been absolutely crucial. Even so, grid companies are reluctant to fulfill their obligations and often have not met designated targets. Despite the REL, there are 'few regulations and instructions on how to connect wind power to the grid' (Zhao et al., 2009). Wang et al. (2010) state, '[I]t is commonplace for grid enterprises to refuse or delay building or expanding grids to connect to renewable power plants.' And there are no reported cases of penalties imposed on grid companies for non-compliance. The main concern, as in Japan, is that renewable electricity fluctuates and destabilizes the net. The grid companies have also been reluctant to make investments in transmission infrastructure. There are five state-owned power generators and two grid companies, essentially functioning as regional monopolies. This may be the biggest barrier to the expansion of renewables, and possibly the most obvious venue for vested-interest battles. The building of transmission lines in coordination with the development of wind power is crucial. A unified grid is scheduled for 2020, but at the moment China essentially consists of seven independently operated grids (Jiang et al., 2010; Schuman and Lin, 2012; Wang, 2010; Wang et al., 2010; Zhang, 2011; Zhang et al., 2013).

Fifth, China is still to a great extent characterized by command-and-control rather than market incentives. Thus, until now targets have typically been for *installation* rather than electricity *generation*, as witnessed by the large proportion of off-grid installations (Schuman and Lin, 2012; Zhang et al., 2013). Subsidies have stimulated mass production rather than technological improvements, and communication between the central government and the provinces is bereft of bottom-up input. Thus, goals and targets are imposed with little guidance as to how the provinces should fulfill them. The focus on capacity also means that success is becoming ever more costly. Subsidies for renewable capacity are paid for through a surcharge on electricity levied on consumers. In 2006 this was CNY0.001/kWh, up to CNY0.008/kWh by 2011. But this is not enough to cover the subsidy. The shortfall increased from CNY1.4 billion in 2010 to CNY22 billion in 2011 and will only keep increasing.[13] Between 2002 and 2008, wind-power subsidies increased 17-fold, which cannot continue forever. Also, the current FIT does not include a tariff-degression formula, as in Western systems. Instead, it states that the government will adjust the tariff based on changes in investment capital and technological improvements, making for a lack of predictability (Hu et al., 2013; Schuman and Lin, 2012).

Finally, the institutional structure is opaque, and provincial authorities have a lot of leverage. Energy regulation in China is confusing, with overlapping responsibilities, diffused authority, and a lack of clarity with respect to interpretation and implementation. This gives rise to bureaucratic in-fighting and to vested interests playing institutions against each other. It hides inefficient policy away inside an institutional structure that defends the status quo without adapting to changing circumstances. China probably needed a ministry of energy to unify and coordinate laws and regulations. Instead, a 2008 bureaucratic reorganization led to the formation of the Energy Bureau, headed by a government minister as well as the Energy Commission. These jostle for power and responsibility with the National Development and Reform Commission (NDRC), the State Electricity Regulatory Commission (SERC) and the energy companies. NEA is the only state-level institution specializing in advanced wind-power technology and equipment, but is not particularly powerful. Finally, national decisions are implemented locally. And so, there has been an array of coordination problems between the state and the local level, even if the 2009 amendment to the REL did deal with some of the problems (Jiang et al., 2010; Liu and Kokko, 2010; Schuman and Lin, 2012; Zhang et al., 2013).[14] But, as important, at the provincial level local governments allocate generation quotas to the power plants. Wind farms increase local revenues to a lesser extent than do thermal plants. Thus, thermal power companies tend to lobby for increased generation quotas, reducing the allocation left for renewables. On days when the power load is low, thermal generation is prioritized, constraining renewables further. Also, there is little electric power trade between provinces. Provinces are unlikely to accept wind power derived from elsewhere as this is seen as undermining local economic growth. Thus, while growth in wind power is strong, we do not have to scratch deeply beneath the surface to find quite serious vested-interest battles (Zhao et al., 2013).

While the vested-interest structure is certainly not unimportant, its exact strength is hard to gauge, for the reason that economic growth is so strong that growth in renewable energy would have happened regardless. But there is little doubt that the lack of a well-functioning grid is a serious problem, and that there are serious differences of interest with respect to its construction. The consequence of the division of authority and responsibilities between multiple agencies, the only partial introduction of market mechanisms, and the fact that national laws are locally implemented, is that there is ample room for vested interests to influence policy. These problems will persist and grow: first, because renewables will keep growing at a brisk pace, exacerbating already existing frictions; second, because it is unlikely that Chinese growth will remain at present levels forever: In a world in which Chinese growth is no longer strong enough that China can essentially prioritize everything (thus, not really prioritizing), interest battles will become more pronounced and genuine policy choices will have to be made. China has powerful energy industries and, if evidence from other countries is anything to go by, these will end up strongly influencing both national energy policies and institutional frameworks and become concrete obstacles to energy reform (e.g., Sovacool, 2009; Moe, 2010, 2012).

Yet, it is hard to attack Chinese renewables policies when the result has been so impressive. And, while the expansion of renewables is driven by demand for energy rather than a purposeful attempt at structural change, growth both in wind and solar has accelerated following government attempts to improve the regulatory and institutional framework. It is likely that renewable energy policy in China started out as industrial policy (with an eye to energy security). PV was an export industry only. However, over the past few years, renewables have also become part of strategy to address air pollution, green industry and technology development, energy intensity and carbon emissions (Liu and Goldstein, 2013; Zhang et al., 2013).

While one might speculate that a non-democratic country like China has more leverage and can act more decisively than Japan, Norway or Denmark, especially as many industrial actors are SOEs, opacity does not normally make for good governance, and the lack of clarity about who the actors are, their preferences, and the responsibilities and jurisdictions of different institutions makes for a system that is easily abused. It is normally a more fertile breeding ground for vested interests than a more open system is. The fact that China has listed both solar and wind as 'new strategic and emerging industries,' set to replace the so-called 'old pillar industries,' including oil and coal, is a good sign. Still, it is likely that future Chinese renewable energy problems will to a significant extent be vested-interest problems. So far, not many tough choices have had to be made, because most of the cracks in the framework are papered over by growth. Thus, vested-interest problems remain maintainable, since in a situation where everyone grows there is no need for vested interests to fight each other to get their way. That will probably change, and while regulatory reform has been a partial success, there are many problems still remaining, and major potential for festering vested interest problems, even if for the foreseeable future, renewables will continue to expand at a very impressive pace.

Norway: hydro and petroleum blocking new renewables?

Norway is one of the world's wealthiest countries. Part of that wealth stems from good institutions, good economic policies, and a high level of technological sophistication. Part of it also stems from an abundance of petroleum, Norway being the world's third-largest exporter of energy (IEA, 2011a). As financial crisis hit the rest of Europe in 2007 and onwards, Norwegian growth continued more or less unabated, a dwindling of exports being the main indication that crises were unraveling elsewhere.

From the 1970s onwards, Norway consciously built a petroleum industry and has reaped tremendous economic benefits from it. Norway pursued structural change, creating and supporting a major growth industry from scratch. And while Norway hit peak oil a while ago, gas is still expanding. The petroleum sector in 2009 accounted for 26 percent of annual investments, 22 percent of GDP and 47 percent of exports (Fermann, 2014), and the Norwegian petroleum company Statoil, owned 67 percent by the Norwegian state, is by far the country's biggest company.

But what happens to renewables in a country that has such a strong bias towards energy industries belonging to what Unruh (2000) refers to as a techno-industrial complex (or, in Norway, a petro-industrial complex)? Has the petroleum industry locked Norway into an industrial status quo, for all practical purposes making it impossible for renewables to rise? While Norwegian wind power has enjoyed a moderate upswing as of late, the overall effort has been feeble. And while Ernst and Young (2013b) holds that prospects for wind power are improving,[15] it is not obvious that the present support framework will be more of a stimulus to wind power than hydropower. Thus, with persistently high investments in the petroleum sector, is the Norwegian vested interest structure so strong that for all practical purposes the indefinite perpetuation of petroleum is the only conceivable way forward?

Old renewables

In one sense it is distinctly unfair to criticize Norway for lukewarm renewable policies. Preceding the petro-industrial complex, Norway was dominated by hydropower. Norwegian industrialization, from the early 20th century onwards, relied on electricity from hydropower, stemming from an abundance of waterfalls and rivers. Even today, 96 percent of Norwegian electricity consumption derives from hydropower, and the share of renewable energy in total primary energy supply (TPES) ranges between 40 and 50 percent (IEA, 2011a; OECD, 2011). The 1950s and 1960s saw the rise of a hydro-industrial complex, resulting from the state's political priority of cheap electricity. This could only be done by going extensively against the market and systematically over-investing in electricity production. And, despite fulfilling the political goals, the sector kept expanding, accompanied by cost overruns and weak oversight resulting from close ties between government institutions, hydropower and energy-intensive industry (Christiansen, 2002; Midttun, 1988). Thus, the first reason that new renewables have, until recently, remained an afterthought, is that Norway was self-sufficient in electricity from hydropower and already had a vested energy interest in hydropower.

However, in 2001 PM Jens Stoltenberg stated that the time for major hydropower developments had passed. With the need for energy steadily increasing, electricity needed to be generated elsewhere, for practical purposes by renewable energy or gas. In 2000, PM Kjell Magne Bondevik had refused to go for gas, but faced a parliamentary majority against him. Stoltenberg, instead, became the new PM and gave the subsequent go-ahead for several gas power plants. His administration did not foresee much of a future for wind power in Norway and also had concerns about intermittency of supply problems. But concerns about a decrease in demand for Norwegian gas from Europe may also have been part of the deliberations that led to gas being preferred over wind (Blindheim, 2013; Hager, 2013).

New renewables

Thus, when Norway *did* experience a need for more electricity, gas was preferred over wind power, and Norwegian efforts in new renewables remained feeble. At roughly 700 MW of installed capacity (2012) Norway is far behind other European countries (Germany has 31 GW and Denmark about 4 GW) despite having a high technical potential for wind power.[16] And while it may be unfair to compare Norway to the frontrunner Denmark, because Denmark was in a completely different situation in terms of electric power, the differences between these two Scandinavian countries with roughly the same populations are telling. In Denmark, wind is one of the most successful industries, in Norway it survives as a subcontractor.

Norway's 1999 goal of 3 TWh of wind power by 2010 was never fulfilled. The year 2012 yielded roughly 1.6 TWh, or about 1.1 percent of electricity supply. In comparison, hydropower delivers approximately 120 TWh of electricity (Blindheim, 2013; Energilink, 2013; Vindportalen, 2013).[17] In terms of government support for wind power, a subsidy of 8 øre/kWh of produced electricity (roughly €0.01) was introduced in 2006. It was the third-lowest rate in Europe (EREF, 2007), and probably less than half of what would have been necessary for any serious number of installations to be built (*TU*, 2008; *Zero*, 2009), leading to a number of actors giving up on wind power. The subsidy was phased out in 2012, when a green certificate system in cooperation with Sweden was introduced. As an European Economic Area (EEA) member, Norway is committed to increasing its renewable energy

Table 14.1 Norwegian and Danish wind-power figures

	Norway	**Denmark**
Employment	200–300[a]	28,500[b]
Turnover (million €)	25–40[a]	11,000[b]
Share of total electricity consumption (2012)	1.1%[c]	27.1%[c]
Total capacity (MW, 2012)	703[d]	4,162[d]

Notes: [a] Buen (2006); [b] *Vindmølleindustrien* (2013); [c] EWEA (2013); [d] WWEA (2013).

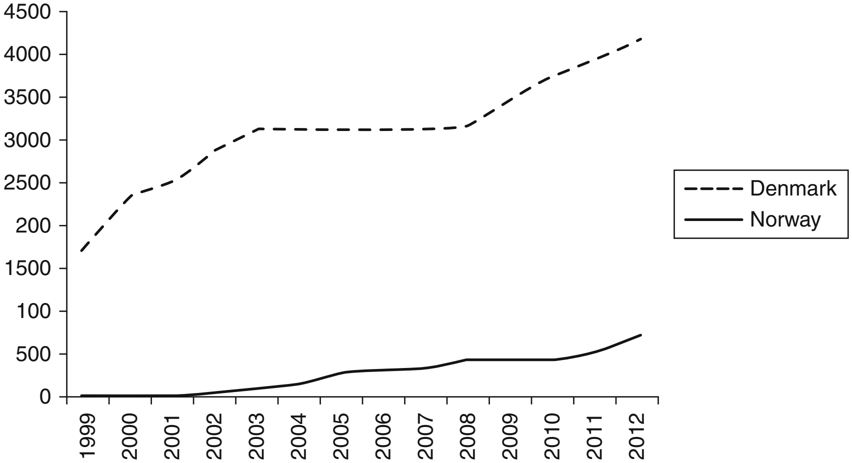

Figure 14.2 Wind power installations in Norway and Denmark, 1999–2012 (MW)
Sources: IEA (2005) and WWEA (2013).

share of electricity production from 58 percent (2005) to 67.5 percent by 2020 (Blindheim, 2013; Europaportalen, 2013). The joint certificate market, through which Norway and Sweden will each fund half of a total of 26.4 TWh of green electricity production by 2020, is the main policy instrument by which this target will be reached (Gullberg, 2013; Hager, 2013). This is, however, a system for the phasing in of *renewable energy*, and not for wind in particular. Thus, more than half of the Norwegian 13.2 TWh will probably come from hydropower.[18] Yet, the fact that between 2002 and 2007 talks and negotiations with Sweden over a certificate system triggered wind-power concession applications for between 5 GW and 7 GW, as opposed to the lowly 0.7 GW installed by 2012 (Hager, 2013), suggests that there is potential for growth and considerable optimism in the business as long as framework conditions are stable and conducive to growth.

However, the certificate system is not being complemented with technology-specific FITs. This means that there is very little room, for instance, for solar PV. For climate reasons one might think that solar was fairly irrelevant in any case, and as compared to Japan's 7 GW of PV, Norway's 0.1 MW of installed capacity is hardly impressive. However, despite the lack of installations, Norway's PV industry has at times had as much as 10–20 percent of the world market of a number of different PV components, with companies such as Elkem Solar and REC (even if in 2011 Elkem Solar was sold off to China, and since 2012 REC no longer does any domestic manufacturing). But as in China, solar PV in Norway was for export purposes only, and never about increasing the domestic energy supply – this despite PV receiving more research funding than wind power (Klitkou and Godoe, 2013).

A vested-interest structure biased towards petroleum?

It made sense for the state to foster a Norwegian petroleum industry. Norway identified petroleum as a sector with enormous growth potential and did a fine job of setting up an institutional structure to cater to its needs. This also means that the institutional structure, consisting of the Ministry of Petroleum and Energy (MoPE) and the Norwegian Petroleum Directorate (NPD) is a major bias in favor of petroleum. These, to a large extent, are allies of oil and gas. The industry recruits from the bureaucracy, and the bureaucracy looks for people with industry connections. Many NPD employees consider it their task to promote the interests of petroleum and to obstruct actors that side against it (Boasson, 2005; Holm, 2007; Ryggvik, 1996; Ryggvik and Engen, 2005). The notion that MoPE should promote renewables seems distant. In 2006, as FITs were discussed, the impression was one of facing a wall of MoPE bureaucrats, none of whom had any belief in wind and, upon asking a senior MoPE bureaucrat if a change of government would make a difference, a Norwea (the Norwegian wind power association) representative was told that it would not, as the bureaucracy would ensure that policies remained stable (Hager, 2013).

Institutions like the Ministry of the Environment (MoE) and the Norwegian Climate and Pollution Agency (NCPA) are far less influential and tend to be overruled. In an interview with newspaper *Aftenposten* in 2006, previous NCPA leader Håvard Holm lamented the fact that whereas the climate section of NCPA has 10–12 people and less than NOK1 million (€125,000) a year for independent analysis and investigation, the MoPE, the NPD, Petoro,[19] the Norwegian Water Resources and Energy Directorate (NVE), the oil companies, and so forth have staffs of hundreds of highly qualified people.

The NVE is in charge of the concession process. However, it takes renewables far longer to get a concession application through the bureaucracy than it does petroleum. An average wind-power application takes four years. At current rates, it will take 40 years to get the already existing wind-power applications through the system (Blindheim, 2013; *TU*, 2007; *Zero*, 2009). The problem is partly one of the NVE not giving wind power much of a priority, but also, those four years are on average split 1.5 years between the NVE and 2.5 years with the MoPE. This is because nearly every application is appealed to the MoPE. The resources spent on appeals are indicative of the MoPE's lack of enthusiasm for renewables. That the 2010 3 TWh goal was unachievable was clear as early as 2007, and a major part of the reason was that the MoPE constituted one of the biggest bottlenecks, both in handling the appeals and in understaffing the NVE (Blindheim, 2013).

Permeating every main government ministry is a language of cost-effectiveness, even by the MoE – so as to be taken seriously (Boasson, 2005). Cost-effectiveness may seem like a good compass. It does however play into the hands of the existing industries, as these are the ones that have had time to become cost-effective. Present-day willingness to support projects long-term in scope has dwindled, which is linked to the requirement that projects be viable from day one. While wind power is not, simply waiting for the technology to improve and electricity prices to rise effectively means missing out. Green certificates constitute one cost-effective solution. This has many benefits, but as Norway has eschewed differentiated FITs, it also means favoring the cheapest renewables, that is hydropower, biomass and to some extent onshore wind, and very much not PV or offshore wind. This bias, and its effect on energy policy-making in Norway, have been pointed out by a number of studies (Blindheim, 2013; Boasson, 2005; Hager, 2013; Klitkou and Godoe, 2013; Moe, 2009; Solli, 2004).

Norway was one of the first countries to impose a carbon tax (1991). However, most of the energy-intensive industry beyond petroleum is exempt (only about 60 percent of the CO_2 emissions are covered). Thus, the petroleum industry is not omnipotent. It does lose battles, and it is heavily regulated. Yet, it is also very clearly at the hub of the Norwegian industrial structure. Combined with technological initiatives on Carbon Capture Storage (CCS), this makes for an industrial future in which Norway keeps walking in the same direction, but at a slightly lower environmental cost. The petroleum industry was not happy about CCS, thus this political battle was also lost. Yet, for the industry it was a lesser evil than the perceived alternative – a steep carbon tax. For renewables CCS implies an unwillingness to pursue structural change. It preserves the existing structure, but makes it slightly more efficient. The lack of a stable and fruitful framework for renewable energy has been pointed out, both in outside reviews, like the IEA (2005), and from Norwegian wind-power actors (Blindheim, 2013; Moe, 2009; Reitan, 1997), even if the IEA (2011a) now sees signs of improvement.

Human capital is also biased towards petroleum. Much of the Norwegian Research Council funding is devoted to petroleum, and a high number of doctoral dissertations are partially funded by Statoil. This means that traditional institutions of research and education provide partially funded research for those actors that are already the strongest. Amongst high-income countries, Norway has, relative to GDP, by far the highest funding for CCS (Buen, 2006; van Alphen et al., 2009). While no renewable research hub has emerged, the national innovation system not being a good fit, Norway instead has an innovation system around CCS (Fagerberg et al., 2009). Between 1997 and 2007 Norwegian public wind R&D expenditures amounted to roughly €25 million (compared to €131 million in Denmark, which probably constituted only 8–10 percent of private Danish R&D (*Vindmølleindustrien*, 2010)). Human capital investment shot up towards the end of the decade but, whereas wind energy in 2010 received roughly €9 million, solar PV, for which there is no deployment program, received €18 million.[20] In comparison, CCS got almost €30 million (IEA, 2011a; Klitkou and Godoe, 2013).

In addition to this, grassroots movements have been skilled at lobbying against wind power. Gullberg (2013, p. 619) cites the following from the *Forum for Nature and Outdoor Life*: ‘We have enough energy in Norway. The potential for energy efficiency and energy recycling is vastly underutilised.…In the future climate measures will pose a greater threat to the natural environment in Norway than climate change.’ A strong Norwegian conservationist strand has opposed both hydropower and wind power, advocating energy conservation rather than production. However, as the perceived choice has ever more stood between gas and renewables, conservationists have softened on renewables. Still, one of the reasons why wind-power applications take such a long time is that almost every application is appealed (Blindheim, 2013). A lack of social and local acceptance is a significant problem (Buen, 2006; IEA, 2005). The fact that countries like Denmark have been far more successful at siting wind turbines, and suffer far fewer local complaints, suggests that it is possible to create contexts in which local communities support rather than oppose renewable energy.

Off-shore wind as a vested interest loop-hole?

While not omnipotent, the petroleum sector certainly influences policy. It is no coincidence that CCS is the favored Norwegian approach to reducing greenhouse gases, despite this looking like an exceedingly expensive solution – ironically the one area in which cost-effectiveness does not seem to matter; a non-cost-effective solution to an approach chosen primarily for cost-effectiveness reasons. Since being trumpeted as the Norwegian equivalent of the moon landing by then-PM Stoltenberg in 2007, it has been heavily subsidized by the state and steadily pushed into the future. The Technology Centre Mongstad, which is a facility for the testing and improvement of CO_2 capture, started operating in 2012, but Britain is still the only country to have implemented policies to drive CCS employment, and in September 2013 the Norwegian government announced that it was cancelling the full-scale Mongstad CO_2 treatment facility (IEA, 2013; *TU*, 2013b).

However, Norwegian off-shore wind has traditionally had more political goodwill than land-based wind, and the question is whether or not this constitutes a vested interest loophole. Off-shore wind fits far better with the institutional and industrial structure, with expertise within off-shore installations and shipping, and is an area in which established Norwegian actors are making inroads. Out of 94 Norwegian companies involved in off-shore wind, 70 percent are also involved in the petroleum or maritime industries. The potential closeness with the petroleum industry could be an asset: In September 2009, Statoil’s Hywind project became the world’s first full-scale, floating off-shore wind turbine, even if it is not obvious whether this is a priority of Statoil’s or just renewable window-dressing (Bellona, 2009; *TU*, 2012). Two publicly financed research centers (Nowitech, Norcowe) focus exclusively on off-shore wind. Yet, while previous petroleum and energy ministers have been quite sanguine about the prospects for off-shore wind,[21] optimism was tempered by previous petroleum and energy minister Ola Borten Moe explicitly declaring that it is too expensive, and that no concrete deployment plans exist (*TU*, 2011).

Thus, while China projects 30 GW of off-shore capacity within 2020, and while Britain is currently the runaway leader with 3 GW of off-shore installations and 75 percent of world capacity, and Denmark the number two with almost 25 percent of its installations off-shore, Norway stands at a measly 2.3 MW. While the above figures refer to non-floating windmills, the enthusiasm once surrounding Norwegian off-shore wind has subsided somewhat. Thus, Norway is succeeding, but by supplying equipment and know-how for an ongoing European expansion (especially off the British coast) rather than through deployments on the Norwegian shelf (*Aftenposten*, 2013; Klitkou and Godoe, 2013).

It leaves the conclusion that, despite a high potential, there are a number of reasons why the overall effort has been feeble. First, no effort was needed. During the 1973 oil crisis Denmark was in a situation in which it had to increase coal imports, invest in nuclear, or find alternative sources of energy. Norway had an abundance of hydropower and discovered oil in the North Sea. But, as Norway now needs more electricity than can be derived from hydropower, the renewable effort is still lukewarm, and gas has been the preferred solution. Above all, what we see is a glaring lack of consistency in renewable policy-making and a blatant refusal to think of energy policy and industrial policy as linked. Wind power has been developed for energy-supply purposes only. PV, however, was exclusively for export purposes, and the same goes for off-shore wind. No source of renewable energy has been about both energy policy and industrial policy. Instead, they are de-linked. Green certificates are accompanied by a national RD&D strategy whereby PV and off-shore wind are prioritized. However, as these are also the most expensive renewable technologies, green certificates guarantee that these are the ones that are the least likely to be actually installed. Thus, research policy favors PV and off-shore wind; deployment policies favor hydropower and onshore wind; whereas tax policies favor petroleum (Klitkou and Godoe, 2013). Add to that an institutional structure that is heavily biased towards petroleum, and there is no doubt that renewables face a tougher future in Norway than they do elsewhere, very much because of a strong vested-interest structure, despite a self-image of being clean and environmentally friendly.

Denmark: A successful case of structural change? Wind power on the inside

When the 1973 oil crisis hit, Denmark was in a very different situation than Norway. Facing the choice between importing energy and finding alternative means of production, with nuclear power a political taboo and with almost no hydropower, energy security concerns set Denmark on a course that eventually made it one of the world's major producers of wind power. Denmark 'engaged in what is probably the most ambitious support scheme for renewable energy technologies ever seen' (IEA, 2006). And the combination of oil crises and nuclear aversion made it possible for governments to link renewable energy policy and industrial policy in a way that never happened in Norway. With climate change an ever-larger political issue, Danish authorities have also seen a clear link between renewable energy promotion and climate policy (IEA, 2011b; Pettersson et al., 2010; Sovacool, 2013).

Denmark not only sought to satisfy its energy needs by renewable means, but built a home-grown industry in the process, fostering the industrial giant Vestas – between 2000 and 2011 the world's largest wind-power company (EPIA, 2013; Nielsen, 2002).[22] With a turnover of €11 billion and 28,500 employees, wind energy is one of Denmark's biggest export industries, with energy technology and equipment constituting 9.5 percent of Danish exports (Buen, 2006; IEA, 2011b; *Vindmølleindustrien*, 2013). At 27 percent, no country derives a larger share of its electricity consumption from wind. And while the installed capacity at roughly 4 GW is dwarfed by many countries, Denmark has the largest capacity per capita and (bar Lilliputians Guadeloupe and Aruba) the largest capacity per land area (EWEA, 2013; WWEA, 2013). Danish wind has grown economically and politically so influential that the belated rise of a petroleum industry has only had a lesser effect.

Denmark is a leader also in the sense that the parliament has decided for the energy system to be fossil-free by 2050. This stems from the 2011 government plan 'Energy Strategy 2050,' which lays out a number of steps to be taken. The first is already being implemented, namely an increase in wind-power production from 25 to 50 percent of electricity demand (IEA, 2011b; Lund et al., 2013).

Granted, not everything is rosy: 2003–08 was a period of almost complete standstill, as a change for more market-liberal policies put an end to wind-power expansion. This was a political change that the wind lobby was unable to prevent. Thus, while more powerful than in most countries, an industry that lives off subsidies will always be vulnerable to political change. Its strength was, however, an important reason that from 2008 onwards, policy changed back in its favor. While wind power has always had a number of supporters within the Danish parliament, its institutionalization within the energy system, the lack of a powerful oil lobby to counter it,[23] the coordination of energy policy-making in a Ministry of Climate, Energy and Building, and the number of companies and jobs connected to Danish wind power, has made it harder to go against wind power in Denmark than virtually anywhere else. Sovacool (2013) describes Danish energy policy as 'remarkably consistent' between 1973 and 1998. With the exception of the years between 2003 and 2008, policies have generally been predictable, with 25 years of broad parliamentary consensus, to such an extent that wind power itself has become a strong structural force and a vested interest. In Denmark, vested interests urge on wind power policies.

Renewables

The lack of both strong rival fossil fuel providers and nuclear, as well as an almost absence of exploitable hydropower means that Denmark fits the assumption that countries with ambitious renewable energy policies have unresolved energy problems and/or an abundance of renewable energy. Still, the degree to which Denmark has undergone structural change in its energy system is greater than almost anywhere else, a testament to what is actually possible within existing political and economic structures. For instance, after 1973 it took Denmark only five years to go from 95 percent dependence on oil for electricity generation to 5 percent (Sovacool, 2013).

Part of this success stems from a long-held human capital advantage. Back in 1891, Paul la Cour received parliament's support to build a windmill for electricity generation. In the 1950s, Johannes Juul headed a new wave of developments, culminating in 1957 with the pioneering 200 kW Gedser wind turbine (Jensen, 2003; Krohn, 2002). With the 1970s rise of the modern Danish wind industry, a wind-power support system was rapidly erected, establishing capital grants for installation of turbines and the right to deliver electricity to the grid at a fixed price per kWh. Then Denmark got lucky. The 1980 'California Wind Rush' was the world's first major commercial market, and Denmark supplied the majority of the foreign wind turbines installed. But between 1986, when the California program ended, and 1990, the Danish wind-turbine industry was nearly wiped out. Only Vestas, Nordtank, Micon and Bonus survived (Jensen, 2003; Krohn, 2002; Vestergaard et al., 2004). Still, path dependencies had given Denmark a head start. In 1978 the government established Risø Test Station, which rapidly developed into one of the most important wind-power research hubs in the world (Buen, 2006; Megavind, 2007). It is one area where the effort of the Danish state is very evident. Its main role became one of establishing certification standards for Danish wind turbines. This required knowledge-sharing and information-sharing, but also forced dramatic quality improvements on Danish turbines (Krohn, 2002; Vestergaard et al., 2004). Risø supports a number of public research programs and works tightly with the industry. Thus, Denmark represents 'a unique hub of skilled laborers and an experienced network of key component suppliers to support turbine manufacturers' (Lewis and Wiser, 2007). The Danish approach has been bottom-up, building on existing comparative advantages as opposed to countries that have tried to create industrial giants from scratch. In this sense, the Danish wind industry has only to a small extent had to fight existing industrial structures, and has found it fairly easy to get on the inside of the structure, a little like PV in Japan. The rise of wind power also coincided with the fall of several agricultural companies. These proceeded to diversify into wind turbines, drawing on their machine production competencies and using their supplier networks and capital base to become the cornerstone of Danish wind energy – Vestas, Bonus, Nordtank (Buen, 2006; Jensen, 2003; Lewis and Wiser, 2007; Megavind, 2007; Vestergaard et al., 2004).

Concerns have been raised that Denmark's human-capital lead is evaporating. The past few years have seen a system shift, as in the scaling up of size and mass production and of the growth of wind power giants and markets outside Denmark, with the pace of development so fast that academic research has difficulty keeping up (Andersen and Drejer, 2006; Vestergaard et al., 2004; *Vindmølleindustrien*, 2010). The industry has turned very global quite rapidly. Andersen and Drejer (2011) submit that while Denmark is no longer the dominant actor that it used to be, it is still doing well, both in terms of human capital, research funding, links and networks. However, the knowledge advantage can no longer be taken for granted. If the industry does not develop and adapt, especially the smaller Danish actors will lose out to foreign competition.

Beyond human capital, the institutional structure has been conducive to growth in renewables. The Ministry of Energy has been coordinating wind power since 1980. Throughout the 1990s, promoting renewables was a primary energy objective. In 2006 the partnership Megavind was formed as an attempt to create an institutional structure to facilitate innovation within Danish wind power, gathering all the major players of the innovation system and preserving the Danish advantage by creating a coherent strategy for wind power innovation and research (Megavind, 2007). Also in 2006, PM Anders Fogh Rasmussen presented a long-term target of 100 percent independence from fossil fuels and nuclear, which then became the Energy Plan of 2006, whereas in 2010 the Energy Concept 2050 again advanced the goal of a fossil-free energy system (Lund et al., 2013; Sovacool, 2013).

The history of Danish departmental reshuffles also tells a story. From 1973 to 1994, the Department of Environment had close connections with the Department of Energy, which in 1994 became the Department of Environment *and* Energy. This reflected the fact that after the 1970s oil crises, energy policy was to a great extent synonymous with environmental policy. However, in 2001 energy policy was moved to the Department of Economics and Industry, reflecting a policy change *away* from renewables towards 'old industry.' In 2005, energy was put under the Department of Transport and Energy, and from 2007 under the new Department of Climate and Energy. The Danish Energy Agency, which among other things has the responsibility for preparing energy agreements, legislation and regulations, also moved to Climate and Energy (since 2011 the Ministry of Climate, Energy and Building), reflecting a more conscious effort at coordinating energy policy and climate policy, and is a policy change favoring renewables.

The 2001 institutional change reflected a change of policy. Unlike in Norway, until then cost-effectiveness had not been an issue. The original drive for wind came from energy security, hence the onus was on energy production and the build-up of a wind power industry, even if this was expensive.[24] Granted, Danish wind power schemes have been relatively cost-effective. Early policies employed demand-side subsidies to co-operatives and private wind-turbine buyers. Thus, wind-power development was characterized by decentralized bottom-up, existing competencies, and on demand from private and cooperative developers to create a home market. The creation of a domestic market constitutes one of the greatest triumphs of the Danish state, populated by domestic companies (IEA, 2006; Jensen, 2003; Lewis and Wiser, 2007; Nielsen, 2002).

However, after 2001, more market-oriented governments sought to streamline energy policy along cost-effectiveness lines. In 2003, R&D funding was cut and the FIT lowered, the argument being that the state should not subsidize a thriving industry. This was accompanied by Denmark, also for cost-effectiveness reasons, now meeting its Kyoto commitments through emissions reductions abroad – like Norway. Consequently, between 2003 and 2008 only 47 MW of wind power was installed (see Figure 14.2). The wind industry argued that part of Denmark's climate commitments should be met through wind power, that no EU country offered lower average prices for wind power, and that with the old regime Denmark would now be producing one-third rather than one-fifth of its electricity from wind (Buen, 2006; EREF, 2007; IEA, 2006). The year 2008 brought a change in government and a political bargain that included a goal to increase the renewable share of energy consumption from 15.6 percent (2006) to 20 percent (2011), with wind-power support increased from a lowly DKK0.1 to 0.25/kWh (€0.013–0.033/kWh). Offshore FITs are awarded according to a tendering system, yielding subsidies in the €0.06/kWh range (IEA, 2011b; *Information*, 2008; Megawatt, 2008; *theenergycollective*, 2013). From 2009 onwards, this has led to renewed growth, in particular off-shore, which is probably where approximately 60 percent of the new capacity until 2025 will be installed (IEA, 2011b). With the goals from the Energy Strategy 2050 implemented, the renewable share of total energy supply should reach 33 percent already by 2020.

However, the support system goes beyond wind. Denmark never had a solar industry, but has been described by EPIA (2013, p. 19) as 'the major surprise of 2012 thanks to a net-metering system.' Thus, Denmark holds a PV capacity of 394 MW, almost all of which was installed in 2012. This is small compared to Japan, but Danish support policies are recent. The FIT amounts to DKK0.60/kWh (€0.08), whereas residential PV units below 6 kW are instead exempt from energy taxes and part of a net-metering program, whereby customers can effectively run the electricity meter in reverse. This program may be scaled back, but it currently corresponds to a FIT of DKK200/kWh (€27) (EPIA, 2013; IEA, 2011b).

For renewables in general, a crucial part of the system is open and guaranteed access to the grid. This has been provided by the Danish Energy Authority since 1985, splitting the grid connection costs between the owner of the wind turbine and the utility company (Sovacool, 2013). This has been extremely important in Denmark, and is sorely lacking in both Norway and Japan.

Vested interests

The Danish vested-interest structure differs profoundly from the Norwegian, as well as from the Japanese and Chinese, in the sense that not only has wind power found itself on the inside of the structure almost from day one (with some notable exceptions), but also that in Denmark wind power has become influential enough and such a prevalent part of the energy system that wind power itself is one of the dominant vested interests. It is supported by the institutional framework, not unaffected by political swings, but with such a large footprint that despite swings, it always has excellent access to political and bureaucratic channels.

In terms of concrete vested-interest groups, Denmark has two strong wind organizations: the Danish Wind Turbine Owners' Association and the Danish Wind Turbine Manufacturers' Association. Established decades ago, they have had time to coordinate. They are also not marginalized by industrial or institutional structures, and their effect on policy has been considerable. Granted, a petroleum industry *has* risen, but wind power interests are already strong. When in 2003 the government sought to alter the course of energy and climate policy somewhat along Norwegian lines, massive pressure from wind power in collaboration with the opposition eventually succeeded in creating a cross-political bargain staking out a more ambitious policy course. This was reinforced in 2008 (Buen, 2006; Eikeland and Sæverud, 2007; *Information*, 2008). Sovacool (2013) gives the renewable energy lobby much credit for the post-2008 changes. Also, while wind power was singled out by the state, it was buoyed by wind-organization lobbying and by public support, and stimulated by research facilities. While not overstating the degree of planning on the part of the state, a number of policies and measures were adopted by the state in order to create an increased supply of energy and a strong and independent domestic industry (Buen, 2006; IEA, 2006; Jensen, 2003; Krohn, 2002; Sovacool, 2013).

Denmark has also gained from wind power from the outset being both local and popular. Local community benefits have been integral to Danish wind power deployment. Many turbines are owned individually or by cooperatives, with the local community and individual Danes as the direct economic beneficiaries.[25] For smaller installations, concessions are left to the local municipalities.[26] Ownership is decentralized, with cooperatives of a few hundred investors typically owning three to five turbines. The 2008 political bargain is meant to facilitate a greater degree of local participation and less centralized bureaucracy, making implementation less top-down and increasing the benefits for the municipalities (Buen, 2006; *Information*, 2008; Megawatt, 2008; Nielsen, 2002). Nielsen (2002) states that turbines are perceived as an integral part of the cultural landscape, exactly because Danish wind has always been a grass-roots phenomenon (Jensen, 2003; Nielsen, 2002; Vestergaard et al., 2004). A study carried out by Energistyrelsen (Danish Energy Authority) in 2006 showed almost 85 percent support for wind power being used 'to a great extent.'

However, as technologies have progressed, there is an obvious tendency towards ever-larger installations. Current wind turbines are five to ten times as expensive as the turbines of only a decade ago. These projects can rarely be undertaken by local communities, making ownership more concentrated and removed from its local origins. Thus, while local support was always part of what made wind power attractive in Denmark, local resistance is increasing as cooperatives and farmers are being excluded from ownership and participation, leading to bigger wind turbines and wind parks being installed at sea, away from the public eye (Sovacool, 2013; *theenergycollective*, 2013).[27]

Denmark serves as a counterpoint to all the other three countries. Strong vested interests within renewables, a strong research effort and the conscientious build-up of a human capital base centered around research hubs of worldwide renown, has meant that this is no longer a new and vulnerable industry. Granted, wind power has still not matured to the extent that subsidies can be removed, but despite some notable ups and downs in terms of policy support, compared to most countries, energy policy in Denmark has enjoyed considerable consensus. It provided the industry with long-term planning scenarios and a solid base for decision-making, which meant that when Danish entrepreneurs made their forays into wind energy, no major institutional structures impeded their progress. Instead, luck, Denmark's energy situation, and path-dependencies in wind power and machine production meant that an institutional structure receptive to the needs of wind rapidly emerged. Danish wind energy quickly ended up on the inside of the institutional structure. No major structures had to be torn down to pave the way for it, but new structures have been built and institutions created to suit its needs. While this has been a success and an example of how quickly it is possible for a country to achieve something akin to an energy transition with fairly moderate political and economic measures, the achievement should not be exaggerated. Denmark still has one of the largest CO_2-footprints on the planet, and if we look at total energy produced in Denmark, 70 percent comes from petroleum (Sovacool, 2013). Also, global wind power has become a rapidly changing big business, and Denmark constantly needs to develop and adapt in order to stay competitive. While a major success so far, its continued and automatic success cannot be taken for granted. Still, in terms of structural change, of the four countries discussed here, Denmark has been by far the biggest success in renewable energy, with wind power solidly on the inside both of the industrial system and the institutional structure.

Conclusions

These are four very different countries: Japan, China, Norway, and Denmark. And, in terms of renewable energy, they have quite different problems. However, once we start looking at their vested-interest structures we immediately realize that, despite their differences, they have a number of commonalities. The vested interests structure in Japan has clearly favored solar over wind, whereas at the same time solar has never been on the inside of the system to such an extent that it could seriously assert itself over the utility companies. But at significant junctures METI has shown support for solar. And with the shock of Fukushima, solar is experiencing improved framework conditions and renewed growth. (Wind, on the other hand, is still lurking in the shadows.) While this may not lead to Japan regaining its position as the world's number one in solar energy, and while it may stimulate Chinese growth as much as Japanese, what it clearly shows is that, in Japan, solar has had far better growth conditions than wind – very much a result of the vested-interest structure.

That Japanese policies may stimulate Chinese renewable growth rather than Japanese, may seem counterintuitive. However China can produce solar cells significantly cheaper than Japan. Thus, as China has profited from generous FITs in Europe, it may now profit from this in Japan. Until recently 90 percent of Chinese profits in solar PV came from sales abroad. Only recently has a home market emerged. However, this market is now growing faster than any other domestic solar market in the world. While currently lagging far behind leader Germany, it would take less than a decade for this to change if present trends are extrapolated. And there is no doubt that China is serious about renewables. There is a clear realization that China has more to lose from global warming than most, and environmental problems are amongst the biggest grievances of regular Chinese citizens. Thus, growth has been rapid both in wind and in solar power, as well as heavily supported by the state. Still, first of all, energy demand is increasing rapidly. Thus, it is an open question whether this is leading to a Chinese energy transformation or not. Coal will be dominant for years to come, and in absolute terms, China is increasing its production of coal, not phasing it out. And, second, if coal were to be phased out, it is not clear that this would happen without major interest battles. At the moment, economic growth keeps everyone inside the Chinese energy policy system happy. But the stellar growth exhibited by China over several decades already can arguably not continue unabated. Once growth decreases, interest battles will be fierce. So far, strong growth and an opaque institutional structure have papered over vested interest differences, but they are very much there, and they are potentially strong.

Norway is a very obvious example of a state that has sunk a lot of finances and effort into one set of energy industries, and has a hard time looking elsewhere. Granted, hydropower is one good reason why Norway never had much of an incentive to go for solar or wind, but now that the need for electric power has gone beyond what hydropower can deliver, the preferred solution is gas rather than renewables. This may be in the process of changing, but people within the wind industry will routinely tell stories about a bureaucracy that caters heavily to the interests of petroleum, and that is simply not particularly interested in anything else, perceiving other energy industries as expensive and unrealistic. Thus, while Norway may not have had much of an incentive to promote renewables, the vested-interest structure consists of institutions that cater quite specifically to the needs of other energy producers, without much apparent change.

In contrast, Denmark is where wind power has come closest to itself becoming a vested interest. Here, the taboo on nuclear power led Denmark to explore alternative sources of energy following the 1970s oil crises. That Denmark already had experience with windmills and that Danish machine producers were looking for new business opportunities were of course a bonus. But the Danish wind-power adventure would not have happened if not for the support of the state. While that support has at times waned – most notably between 2003 and 2008 – suggesting that political swings can be more important than the political influence wielded by the industry, in general political support has been remarkably steadfast over the past 25 years. Over this period, the industry has become one of Denmark's biggest, Vestas has become one of the world's biggest wind-turbine producers, and the industry has built a lot of political influence. It is considerably easier for Danish wind to get politicians to listen to their needs than it is for Norwegian wind.

What we can quite clearly see in all four countries is that the vested-interest structure is something that always needs to be taken into account. Ignoring it makes it impossible to get a full grasp of energy policies in countries with strong petroleum interests, in countries with strong wind interests, and in countries with major unresolved energy needs. While there are obviously other explanations as to why countries install renewable energy (or do not), vested interests are among the most important and the most interesting. It is an explanation that is about technology, about economics and, not least, politics. It is an explanation that centers on what it takes to make major changes to the (energy) structure of the political economy of a country. Which have also been core themes running throughout the length of this book.

Notes

1. See among others Eikeland and Sæverud (2007).
2. Vested-interest structures consist of more than just concrete interest groups seeking to influence concrete issues. Concrete interest groups are part of the structure, but it also consists of the institutions that have sprung up around the main vested interests and of the routines or rules of thumb according to which these operate. It is the existence of an entire vested-interest structure that makes structural change so hard to accomplish.
3. Known as *ama-kudari*, or ‘descent from heaven’.
4. In the 1968 Long-Term Plan, the first fast-breeder reactor (FBR) was scheduled for the early 1980s. Japan has spent ¥1 trillion ($12 billion) on a prototype (Monju). However, after 50 years of research, the first actual FBR is still not expected until 2050 (*Asia Times*, 2011a).
5. Pre-Fukushima, the 2007 Niigata earthquake caused radioactive leaks at the local nuclear plant. Other accidents involve a sodium leak at the Monju FBR (1995), a fire at the Japan Nuclear Cycle Development Institute waste facility (2003), a critical accident at Tokaimura (1999), and scandals over cover-ups of safety inspection procedures (2002).
6. Fukushima prefecture has for instance received ¥188 billion ($2.3 billion) in subsidies since 1974 (*Japan Times*, 2011a).
7. It still contains a bias in favor of solar as the rate for solar energy is roughly twice that of other renewables (*Bloomberg*, 2011).
8. The IEA considers the lifespan of a nuclear reactor to be 40 years. Three reactors are already more than 40, whereas 16 will be more than 40 and another 17 more than 30 (Japan Times, 2011a).
9. The LDP and Keidanren opposed it, resulting in a compromise whereby energy-intensive industry was given an 80 percent discount on any FIT-related increase to the electric bill.
10. Projected to rise by 45 percent between 2009 and 2020 (Zhang et al., 2011).
11. In 2009, the Chinese market consisted of 70 wind-turbine manufacturers; 29 SOEs and state-holding enterprises; 23 private enterprises; 10 foreign-owned and 8 joint ventures (Zhao et al., 2012).
12. The Wuxi city government, however, immediately bailed Suntech out. Other local governments have done similar things. Ernst and Young (2012) predict that more than 50 Chinese solar module manufacturers will go bankrupt by 2015. So far, local governments have, however, been extremely reluctant to allow this, subsidizing ever more ‘solar zombies’ (*Economist*, 2013a; *Reuters*, 2013).
13. Schuman and Lin (2012) report a projected CNY710 billion in subsidies for 2011–20. In comparison, Germany in 2012 paid a total of €16 billion for all forms of renewable energy through its FIT (*Economist*, 2013b). CNY710 billion equals €90 billion, thus over a ten-year period, this is clearly less than in Germany. However, these subsidies are driven by solar rather than wind, and Germany has installed 32 GW of solar PV capacity compared to China’s (at the time) 3 GW. Thus, China’s expenses will increase more rapidly, as Chinese PV is expanding extremely rapidly.

14. Like the 50 MW loophole: Wind farms smaller than 50 MW only required local approval, leading to a flurry of 49.5 MW wind farms popping up, without grid-lines being planned, larger wind farms split into 49.5 MW components, etc. (Schuman and Lin, 2012; Zhang et al., 2013).
15. In the August 2013 renewable energy country attractiveness index, Norway was 13th out of 40 countries in on-shore wind attractiveness, up from 18th in 2012 and only marginally behind Denmark (Ernst and Young 2012, 2013b).
16. 76 TWh/year compared to 29 TWh/year for Denmark, for instance (Buen, 2006). In addition to this comes a potential 18–44 TWh of off-shore wind power (Gullberg, 2013).
17. Some years are wet, others dry. Thus, hydropower production fluctuates. Between 2000 and 2008, production varied between 106 and 142 TWh (Energilink, 2013).
18. The NVE suggests a new hydropower potential of 33 TWh of production, whereas concessions, notifications and applications for wind power accounts for 43 TWh (Gullberg, 2013). *TU* (2013a) suggests that a minimum of 7 TWh of the Norwegian share will come from hydropower and maybe a full 15 TWh.
19. Petoro is owned by the Norwegian state, and manages Norwegian offshore petroleum properties and the State's Direct Financial Interest on behalf of the government.
20. PV has been more generously funded than wind ever since the 1970s (Kliltkou and Godoe, 2013).
21. The parliament in 2010, for instance, passed an act on off-shore renewable energy, which included identifying suitable sea areas (IEA, 2011).
22. With 14.0 percent of the wind-turbine world market, Vestas in 2012 lost its position to the U.S. GE Wind (15.5 percent). This could however be because of the U.S. market being particularly strong that year (REN21, 2013).
23. Since 1998, Denmark has been self-sufficient in petroleum. However, reserves are dwindling, and at current rates, Denmark will be a net importer by 2018 (Sovacool, 2013).
24. Wind-power support has come at a price. With CO_2 emissions valued at DKK270 (€36) per ton, 1990s support for renewables represented a negative investment as a whole. The 1992–99 net present value of subsidies amounted to DKK -3 billion (€ -0.4 billion), of which subsidies and preferable taxation DKK25 billion, environmental benefits DKK20 billion, and DKK2 billion from the growth of the windmill industry (IEA, 2006).
25. In 2002, 80 percent of Danish wind turbines were owned by co-operatives and individual farmers (Krohn, 2002).
26. The Risø National Laboratory administers the wind power approval schemes created by the Danish Energy Authority.
27. A study by Energistyrelsen (Danish Energy Authority) (2006) suggests that the willingness to pay to have wind farms located at sea is considerable. It increases by 100 percent from 12 to 18 km, and by another 33 percent from 18 to 50 km.

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15

Conclusions

Paul Midford

This book has attempted to bring together social science perspectives on energy security and renewable energy with engineering and natural science perspectives on energy technologies. The idea has been to combine deep insights about emerging energy technologies with analysis about the social impacts of these technologies. At the same time, technological diffusion and application are not simply a function of the technology itself. Rather than following a technological dynamic, the diffusion and application of technology often follows a social logic. This is especially the case with the energy sector, where pre-existing institutions, stake-holders, and ideas often have a powerful impact on which new technologies are adopted and which are not. This cross-national study has proven to be the idea vehicle for analyzing this dynamic. Although the technology available in China, Japan, and Northern Europe is essentially the same, the choices and adoption of technologies have varied tremendously among these countries.

One of the central conclusions of this volume is that renewable energy and energy security have now become inextricably linked. This reflects both the increasing limits and costs of heavy reliance on fossil fuels, especially the environmental impacts, and the increasing economic challenges facing nuclear power in the wake of the ongoing Fukushima Daiichi nuclear accident. Three characteristics of renewable energy systems have real value for energy security: their environmentally friendly nature, their presence, albeit in varying combinations, in all countries; and the promise they offer for more decentralized, local, and less complex and vulnerable energy networks.

Another major conclusion that emerges from this volume is that the technology for generating electricity from renewable sources of energy – most notably wind, and solar – has developed rapidly over the past three decades. Solar and wind have transformed from being on the frontier of research and development in the case of solar, or a boutique industry in the case of wind, into dynamically growing global industries. Emblematic of the growing centrality for major economies of industries that manufacture hardware for renewable energy is the high-stakes political confrontation that played out between the EU and China in 2013, a confrontation that for a time threatened to trigger a large-scale trade war between the two sides. That France came to the brink of sacrificing one of its most important markets for one of its most important exports, wine, simply for the sake of reducing Chinese solar photovoltaics (PV) exports to Europe tells us a lot about how important trade in PV solar panels has become (Emmott, 2013).[1]

Wind, and especially PV solar, have all the characteristics of technologically dynamic sunrise industries where rapid technological advance goes hand-in-hand with rapid declines in price. This is especially true with PV solar, a technology related to the semi-conductor industry that spawned the IT revolution of the past three decades; PV solar is advancing at only somewhat more modest rates. Globally, the growth of wind, and especially PV solar, industries has to a significant extent been propelled by a relatively pure technological logic, one supplemented by an economic logic of global free trade.

However, this volume also illustrates the very large differences in the rates at which diverse countries have adopted and diffused wind and PV electricity generation. China, Denmark, and Germany have been the leaders in adopting these technologies to meet their energy needs, whereas Japan and Norway have been the laggards, and the UK (and perhaps Sweden) serves as a model of a late adopter. It is these very differences in national rates of adoption that draw our attention away from the influence of technological dynamics and toward national-level social and especially political dynamics. The degree of energy security, domestic public opinion, civil society and interest groups, and what Unruh (2000) calls techno-institutional complexes (TICs) in the energy sector are major factors that help explain very different national responses to the opportunities presented by rapid progress in renewables technology.

Danish leadership in wind power was a response to energy insecurity in the wake of the oil crises of the 1970s, and despite Denmark's modest production of oil and gas. Nuclear power never established a foothold in Denmark, and there were no other vested energy interests strong enough to block the growth of the country's wind industry. The wind industry got an early start in Denmark, with the country developing pioneering wind turbines already in the 1950s.

Energy insecurity was also a major motivating factor in the case of Germany. Unlike Denmark, Germany did establish a nuclear industry. However, the growth of opposition to nuclear power in civil society, and especially the growth of opposition in public opinion after the Chernobyl accident, limited the institutionalization of nuclear power in Germany and created a policy space for promoting renewables as an answer to energy insecurity. Given the country's size and its advanced industrial base, the promotion of renewables also provided opportunities for German industry in wind power and especially PV manufacturing. Indeed, the combination of Germany's substantial feed-in tariff (FIT) subsidies combined with Japan's ending of its solar subsidies in 2005 allowed Germany to wrestle global market leadership from Japan in 2006 (although a few years later Germany lost this position to Chinese manufacturers).

Norway, on the other hand, is the only country examined in this book that has enjoyed energy security, which has been due to its large oil and gas industry, and also to its large hydro-electric power industry that supplies over 95 percent of Norway's domestic electricity needs (see Chapter 14 by Moe). This combination of two strong energy industry incumbents plus a lack of energy insecurity has created a negative environment for renewables in Norway. When it became evident at the turn of the 21st century that growing electricity demand would outstrip the supply available from hydro, the Norwegian state decided to build gas-fired thermal plants rather than turn to new renewables such as wind and solar. At the same time, subsidies and grid access for wind power in Norway have been modest at best.

Energy insecurity was also a major motivating factor for China. Although a net oil exporter until the early 1990s, China's economic take-off turned the country into a large net importer of oil, and given China's lack of an alliance with the global military and naval hegemon, it was insecure about its access to overseas sources of oil. This encouraged the Chinese Communist state to move ahead full throttle with the development of all conceivable domestic energy sources, including coal, nuclear, large-scale hydro and, since the beginning of the 21st century, renewables such as wind and solar, in order to stay ahead of breakneck economic and energy demand growth. As Espen Moe notes in his chapter on vested interests, promoting all domestic energy sources at once minimized potential conflicts of interest among these energy industries as distributional trade-offs among them essentially did not arise. In this environment it was relatively easy for renewable energy to expand rapidly, thanks to government subsidies, priority access to the grid (at least in theory), and a relative lack of political conflict with other energy industries.

Another factor that might help renewables in China is the presence of a relatively strong state that is apparently not as easily penetrated by societal and special interests as are the liberal democracies focused on in this volume. A final factor favoring the growth of renewables in China were apparent economic opportunities to not only enhance energy security, but also to create globally competitive export industries, opportunities that were especially realized in the case of solar PV, where China came to dominate the global market in a few short years, with a 60 percent market share. China has also had some success building its wind-turbine industry into a globally competitive one, although its global market presence, while improving year by year, remains relatively modest.

Finally, turning to Japan we see a country characterized by extreme energy insecurity combined with a strong incumbent energy industry in the form of nuclear power. Nuclear power emerged as Japan's leading answer to acutely felt energy insecurity in the wake of the 1970s oil shocks. The Japanese state also assumed a global leadership role in developing PV technology, but even when the government moved beyond investment in research and development and started subsidizing the diffusion of solar capacity in the 1990s, this was mainly done as a way to help solar become an important export industry, and only secondarily as a supplementary source of energy security in addition to nuclear power. Nonetheless, public concerns about nuclear safety, especially at the local level, caused Japan's ambitious nuclear expansion plans to essentially grind to a halt by the turn of the century.

The Fukushima Daiichi nuclear accident broke this deadlock in nuclear policy, as ambitious plans to further expand nuclear power were dropped and, in the face of the formation of a wide and stable majority opposing nuclear power, the Japanese government decided to phase out nuclear power, albeit over the course of more than a quarter of a century. Accompanying this decision was another to greatly expand support for renewables by instituting a German-style FIT, one that boasted some of highest subsidies for solar and other forms of renewable energy. Nonetheless, solar continued to be the favored renewable, while wind, which had been almost stagnating before 3–11, benefited little from the new FIT (although this is due to the short duration of subsidies, not to an inadequately low level).

The results of these case studies are summarized in Figure 15.1. The results suggest that the strength of vested interests is the strongest determinant of whether nations adopt policies promoting the diffusion of renewable energy. As the degree of energy insecurity increases so too does the willingness to promote renewable energy; however, the correlation between energy insecurity and the promotion of renewable energy appears to be weaker in the case of Japan before the 3–11 quake, tsunami, and Fukushima nuclear accident. Although the United Kingdom was not examined in this volume, its strong oil industry suggests a significant degree of energy security (although not as much as in the case of Norway), yet the country has taken steps over the past decade to aggressively promote renewables, mostly in the form of off-shore wind power, where the UK now boasts more capacity than the rest of the world combined and is aiming to produce up to 20 percent of its electricity from off-shore wind by 2020: currently, it produces around 10 percent of its needs from wind (Renewable UK, 2013). Given that the UK's oil industry is also off-shore and involves many of the same technologies and support industries, this pattern suggests significant synergies between the two industries, as is the case with off-shore wind and oil production in Norway.

The finding that vested interests are a more influential factor than energy security in determining national policies for promoting renewables is not

		Energy Security	
		Secure	Insecure
Vested Interests	Strong	Norway Little or No Promotion of Renewable Energy	Japan (before 3–11) Little Promotion of Renewable Energy
	Weak	Sweden UK Moderate Promotion of Renewable Energy	China Denmark Germany Japan (after 3–11) Strong Promotion of Renewable Energy

Figure 15.1 The determinants of renewable energy policy

surprising, given that energy companies are some of the world's biggest industrial giants (including seven out of the top ten) (CNN, 2013). They can and do wield significant political influence, securing for themselves institutional setups that further their interests. Consequently, in many countries, there is a strong institutional bias in favor of the present energy structure, based on fossil fuels, sometimes nuclear power, and on vast centralized energy utilities distributing electric power to a vast number of industries and households.

The penultimate lesson that emerges from this volume is that the main challenges facing renewable energy over the next two decades do not focus on increasing the efficiency or cost effectiveness of wind or solar.[2] Costs for both are rapidly declining and technological development is continuing apace; no fundamental technological barriers stand in the way of both sources overtaking fossil fuels in price competitiveness. Rather, the main technological challenge comes from integrating renewables into centralized and inflexible electricity grids. This challenge will first become acute in renewables frontrunners such as Denmark and Germany, where renewable energy already supplies more than a quarter of their electricity usage, and where governments are aiming to increase this ratio to 50 percent, and eventually to 100 percent. The fluctuating nature of wind and solar power mean that major changes will have to be made to the grid and its management.

Smart grids that enable electricity usage to be adjusted in response to variations in supply are one key means for increasing the share of renewables in total supply.[3] Another necessary measure is to dramatically increase the capacity to store electricity. Existing capacity, plus some expansion of current technologies, such as pump-hydro and chemical batteries, to store electricity, will contribute to smoothing out the variability problem in the short run. Other less widely used, but not new, technologies will increasingly fill the growing demand for electricity storage: flywheel storage[4] and hydrogen-storage.[5]

The final lesson that emerges from this volume is that the real barriers to the widespread replacement of fossil fuels with renewable energy sources, especially in the large-scale electric utility sector, are not about technological breakthroughs or even significant technological evolution. For too long energy-policy debates have been dominated by discourses regarding technical feasibility, but few policy areas are now more political than energy. Even in the area of electricity, flywheel storage is already industrially used, and hydrogen storage, a 19th-century technology, is widely used on a small scale, although the efficiency of hydrogen storage needs to be improved (Beacon Power, 2013; Scotland.gov, 2010). Rather, the major barriers come in the form of vested interests in national electricity sectors, the need for legal and regulatory change to allow renewables to expand and compete in electricity markets and, above all, large-scale investments to achieve economies of scale and further technological evolution. Structural change in energy, as in other sectors, does not simply happen by itself, pushed by the market's invisible hand. Political choices that allow the invisible hand to operate, not technological barriers or even cost, will ultimately determine whether renewable energy comes to replace a large proportion of the fossil fuels currently in use for electricity production. Major steps in this direction have already been taken.

Notes

1. Similarly, the U.S.-imposed sanctions on Chinese solar PV exports in 2012. See Palmer (2012).
2. Although cost effectiveness is a moving target that can move in both directions. The shale gas revolution in the United States has slowed the growth of solar and wind power there, but notably has not stopped it. Nonetheless, new fossil fuel finds and dropping fuel prices could slow the adoption of renewables even with the continued rapid fall in the price of renewables.
3. For an introduction to smart grids, see Achenbach (2010).
4. A spinning flywheel rotates in a vacuum cylinder that is powered by electricity (in this case production from renewable sources), and powers an electric generator with its kinetic energy when additional electricity is needed. See Beacon.com (2013) and Scotland.gov (2010).
5. Hydrogen storage involves using surplus electricity to break water down into hydrogen and oxygen through electrolysis, and then recombine them in a fuel cell that produces electricity when needed. This technology was first developed in the 19th century. See Scotland.gov (2010).

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