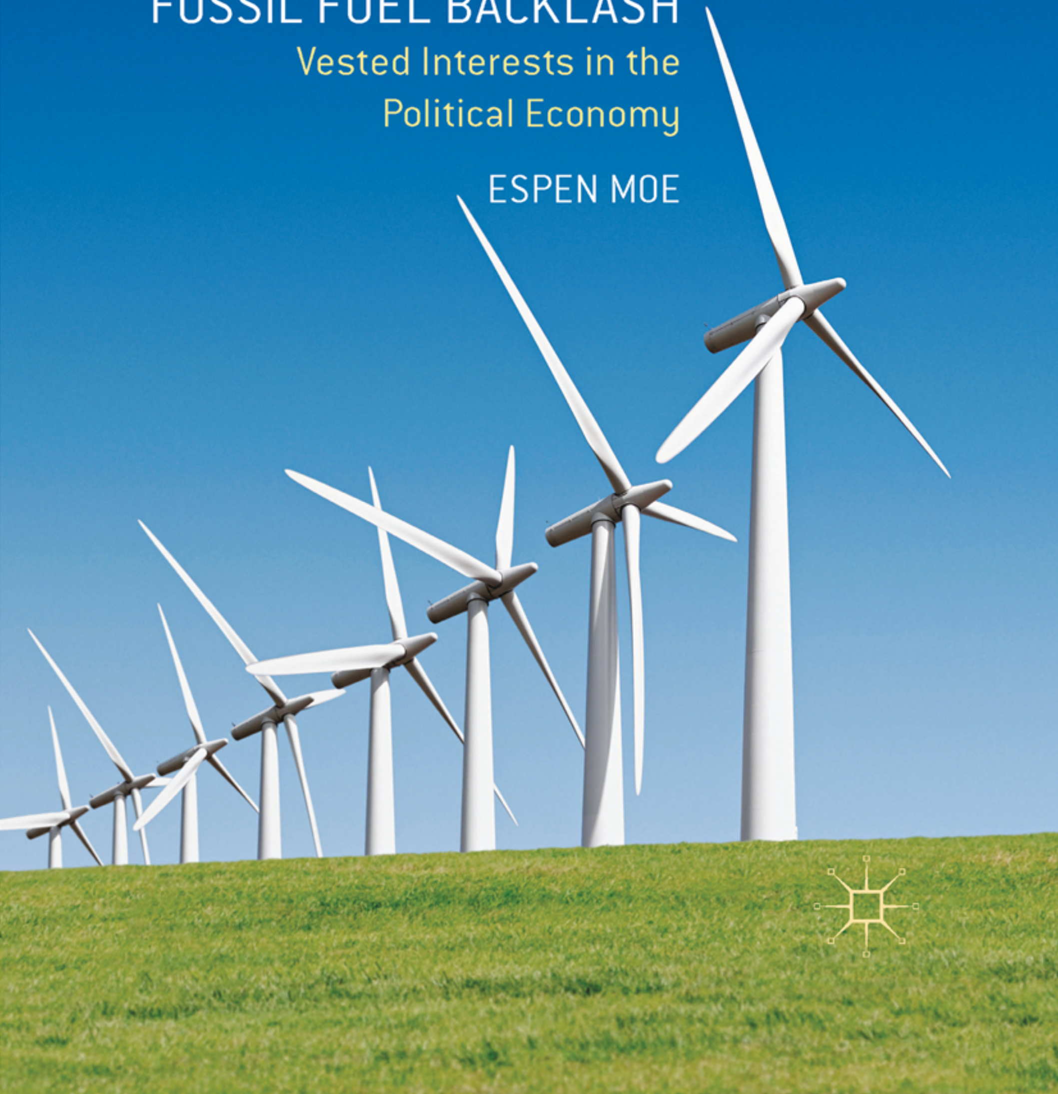
Energy, Climate and the Environment

RENEWABLE ENERGY TRANSFORMATION OR FOSSIL FUEL BACKLASH

Vested Interests in the Political Economy

ESPEN MOE



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Renewable Energy Transformation or Fossil Fuel Backlash

Vested Interests in the Political Economy

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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 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 do now, 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 changes in lifestyle choice – 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 color, the ostensibly technical debates. In particular, at times, technical assertions can be used to buttress specific policy frameworks in ways which subsequently would 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, 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 identifying the shortcomings of these views.

The present text deals with a major issue – why, despite its obvious relevance as part of the response to climate change and concerns about energy security, the development of renewable energy technology has been relatively slow around the world. The obvious explanation, that it looks expensive, does not seem to be sufficient, given that most technologies become more economically attractive if they are developed. This book argues that renewables have fallen foul of opposition from groups with vested interests in the technological and economic status quo. Fortunately, as the book shows, that reaction is beginning to break up, as the economic and strategic attractions of the development of alternatives to fossil and nuclear technology become more apparent. It provides examples from around the world, exploring the emergence of the new more positive view and its implications. The pattern is uneven, as is illustrated by the national case studies. They include major players – the US, China, Germany and Japan – who are all in the process of accelerating the expansion of renewables at various rates, alongside smaller players such as Denmark and Norway, the former being a pioneer in wind power, with huge ambitions for the future, and the latter increasingly being seen as the energy storage "battery of Europe", given its large hydro reservoir capacity, but so far having not developed new renewables to a significant degree. Although, as this book shows, the transition to renewables is occurring at different paces around the world, it clearly represents a major challenge to the energy status quo.

Preface and Acknowledgments

To trace the origins of this book we have to go back a few years. In 2006, I was awarded a postdoctoral fellowship at the Industrial Ecology Programme at the Norwegian University of Science and Technology (NTNU) in Trondheim. I was a political scientist and in the process of publishing my first book, a kind of rise and fall of the great powers (*Governance, Growth and Global Leadership*, 2007), with the onus on long-term structural economic change since 1750. In essence it was a book on the politics of industrial transformations. Thus, industrial ecology seemed a major departure from my previous work.

However, I was being welcomed to Industrial Ecology by Edgar Hertwich and Helge Brattebø who invited me to bring my theories and models from political science and apply them to a very different field. At the program, they were highly interested in finding out what implications my perspectives on the economic and industrial rise and fall of great powers, technological innovation, structural change, economic transformations, vested interests, and Schumpeterian creative destruction could have for energy. Thus, a connection between political science and industrial ecology was created. I told them that the processes governing structural change within industry were highly likely to govern structural change also within energy – after all, the energy area is dominated by some of the strongest industrial actors in the world, which could easily make energy transformations even harder to accomplish than regular industrial transformations (I explain this in greater detail in the Introduction chapter). And I told them that it would be hard to find an energy transformation much larger and with more wide-ranging consequences than the one that we are facing today, namely one from a world based primarily on fossil fuels to one based on renewable energy. Such changes are often complicated both by technological problems and economic problems, but typically there are political constraints as well. And these are as problematic as the technological and economic ones, and often harder to circumvent, because politics operates according to a different logic than technology and economics, one that involves interest coalitions, veto players, and the obvious rationale that no political decision should be so brave as to lose you the next election – in other words, there is a huge human factor.

I kept spending ever more time on this most recent and tentative process of structural change. In other words, why is it that some countries pursue renewable energy so much more eagerly than others. And as you will find out in this book, my suspicion then, and my conclusion now, is that the main answer centers on a political economy of energy that is constrained by vested interest power, and where only those states that actively pursue renewable energy at the expense of these vested interests will have much success in pursuing any kind of energy transformation.

Major parts of this book became a reality paper by paper, so to speak. As I kept working on renewables, I kept seeing the same processes play themselves out in country after country, more or less irrespective of whether the country was an energy exporter or an energy importer, hosted large or small renewable resources, or had major or minor energy problems. Thus, gradually, the idea was born to create a kind of unifying theme to bring all these cases together within the same theoretical framework and literary format, resulting in this book.

What this prolonged gestation period also implies is that there are many years over which I have accumulated intellectual debts to people who have either read or provided feedback on parts of the manuscript or contributed in other ways. The earliest origins of the Norway chapter (Chapter 7) go back to a 2007 conference in Oslo, which in 2009 became a chapter in a book edited by my colleague in the Department of Sociology and Political Science at NTNU, Gunnar Fermann. The beginnings of the Japan chapter (Chapter 2) can be found in work and interviews conducted whilst on a Japan Society for the Promotion of Sciences fellowship at the Kwansei Gakuin University in Kobe-Sanda in 2009, hosted by Yukinori Nakano. I did some tentative field work in Beijing in 2006, and then presented a paper on Chinese renewable energy the next time I visited China, in Dalian in 2011. Thus, some of these chapters have their humble beginnings in field work, conference papers, and presentations that go quite a few years back in time. But it was not until 2012 when I talked to an interested Christina Brian at Palgrave Macmillan about a full book on the political economy of renewable energy that things picked up speed, eventually materializing into the book that you are now reading through. At Palgrave Macmillan it has been a pleasure to work both with Christina, and later with Ambra Finotello.

While my argument has remained more or less the same, presentations, paper drafts, book chapters, and articles have obviously changed considerably (and also pretty continuously) since the early days of the project, as a consequence of the steady unraveling of technological,

economic, and political changes within energy, and as the consequence of me learning more about the field, and being able to draw upon the assistance of ever more people. I have, for instance, benefited greatly from feedback at conferences, where I have presented drafts of several of the chapters. At the past two National Norwegian Political Science Conferences (in Bodø and Tromsø), my appreciation goes to Marcus Buck, Morten Bøås, Arild Farsund, Carl Henrik Knutsen, and several others. They, among other things, told me that the Introduction chapter was boring and that I was best advised to start completely afresh. They were right. Thus, the present Introduction bears only a glancing resemblance to the rather awkward piece that was hurried in place for Bodø in 2013. The past two International Studies Association conferences (San Francisco in 2013, Toronto in 2014) were also very useful, as comments from Robert Cox, Mariam Dekanozishvili, Wolfgang Sterk, and Wojtek Wolfe provided valuable inputs on my papers and on relevant literature on Japan, China, and Germany. The book also got impetus from a conference that I organized on the behalf of the NTNU Japan Program in Trondheim in 2011. The conference resulted in a book in its own right, also with Palgrave Macmillan, *The Political Economy of Renewable Energy and Energy Security*, edited by myself and Director of the Japan Program, Paul Midford and published in 2014. But, more importantly, it brought together expertise on Japan, China, and Norway (and later Germany), and created a group of people that I have been able to draw on for this book as well.

While my appreciation genuinely extends to all the chapter contributors for that project, I should highlight contributions from Kenji Asano, Karolina Jankowska, Paul Midford, Audun Ruud, Yu Wang, and Eric Zusman. Paul has read and commented on much of my work on Japan and both he and Kenji have been helpful discussion partners. Karolina was a great help when I wrote the Germany chapter. Without Audun, my awareness of the importance of grid line problems would have been far weaker. And Yu and Eric have been terrific resources on China. I was also much honored to receive support and helpful comments on my Japan chapter by member of the lower house of the Japanese Diet, Taro Kono, as well as during the EJARN conference in Trondheim in 2014 from Director of the Institute for Sustainable Energy Policies in Japan (ISEP), Tetsunari Iida. Thus, a special thanks to everyone who participated in these conferences and my thanks for the cooperation that led to our 2014 edited volume.

In addition to this, not only were Kenji's and Yu's chapters highly informative, but the two were also very helpful in providing me access to the latest energy data from Japan and China, as well as making the data comprehensible to someone with only an incremental understanding of their native languages and with an equally underwhelming understanding of Chinese/Japanese characters. Tetsunari Iida was also helpful in providing me with numerous Japanese data. Matt Roney at the Earth Policy Institute and GTM Research also need to be mentioned, for granting me access to their latest solar cell and module production data from what are still unpublished datasets. Certainly, by the time a book is actually in print, most quantitative data will already be a year old (thus, essentially one year out of date), and that's as updated as it will ever be! Thus, for the very latest production figures and statistics, one would be better advised to go to the annual reports of, for instance, EPIA, EWEA, WWEA, or REN21. Thus, this book should primarily be read for the argument that it makes and the way it goes about substantiating it. However, the datasets that Matt and GTM provided me with went a long way toward resolving a number of annoying inconsistencies in the data. Thus, they, for instance, enabled me to make conclusions with far greater certainty on the developments of solar power in Japan following the 2011 earthquake and tsunami in Fukushima.

I have also had the opportunity to try out my material in the lecture hall. I want to thank the Institut für soziale Ökologie at the Alpen-Adria Universität Klagenfurt in Vienna for inviting me to teach there in January 2013. While a cross-disciplinary department, it hosts more natural scientists than social scientists. Thus, this was a brilliant opportunity to discuss science and technology. Like, for instance, the state of the art and potential developments within renewable energy, and things like the future of shale gas (and oil). At a time when the IEA and a number of news media were glowing about the prospects of shale and proclaiming the end of peak oil for all foreseeable future, the social ecology faculty was deeply skeptical about what they perceived of as shale hype and a shale bubble. With the IEA (and others) since radically downplaying their earlier optimism, as of now it seems that Vienna got it right; a thank you to Marina Fischer-Kowalski, Daniel Hausknost, Fridolin Krausmann, Julia Steinberger, and my students there. I was also honored to be asked to teach at Beijing Normal University in the fall of 2014, which gave me a chance to try out my China chapter (Chapter 3) on Chinese students and academics; a big thank you to Qing Tian for setting this up.

A number of my colleagues in the Department of Sociology and Political Science at NTNU must also be mentioned. At various times they have either read parts of the manuscript, been involved in the process as discussion partners, or had to endure complaints and questions on the basics of writing, publishing, and the not always successful art of balancing work and life. Thus, a debt of gratitude to Jennifer Bailey, Terje Eikemo, Gunnar Fermann, Susanne Therese Hansen, Torbjørn Knutsen, Paul Midford, and Jonathon Moses. Also, every so often the classroom flips, and students turn into teachers. Supervising Master's students is a splendid opportunity for the supervisor to learn. Thus, I have gained valuable and relevant knowledge from so many of the theses that I have supervised over the past few years.

Finally, after emphasizing that all errors and omissions are obviously the sole responsibility of the author, no acknowledgment would be complete without a heartfelt thanks also to friends, family, and last but not least my wife for support, comfort, and encouragement.

List of Abbreviations

ARPA-E	Advanced Research Project Agency-Energy (USA)
ARRA	American Recovery and Reinvestment Act
AWEA	American Wind Energy Association
BDEW	Bundesverband der Energie und Wasserwirtschaft (The Association of Energy and Water Industries [Germany])
BDI	Bundesverband der Deutschen Industrie (Federation of German Industries [Germany])
BEE	Bundesverband Erneuerbare Energie (The German Renewable Energy Federation [Germany])
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Research and Technology [Germany])
BMU	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment [Germany])
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy [Germany])
BSW-Solar	Bundesverband Solarwirtschaft (German Solar Industry Association)
Btu	British thermal unit
BWE	Bundesverband Windenergie (Federal Wind Energy Association [Germany])
CCS	carbon capture storage
CDU	Christlich Demokratische Union Deutschlands (Christian Democratic Union of Germany)
CMA	China Meteorological Administration
CSU	Christlich-Soziale Union in Bayern (Christian Social Union in Bavaria [Germany])
CTL	coal-to-liquids
DEA	Danish Energy Agency (Energistyrelsen)
DoD	Department of Defense (USA)
DoE	Department of Energy (USA)
DPJ	Democratic Party of Japan
EEG	Erneuerbare-Energien-Gesetz (Renewable Energy Sources Act [Germany])
EIA	U.S. Energy Information Administration

EPA	United States Environmental Protection Agency
EPIA	European Photovoltaic Industry Association
EREF	European Renewable Energies Federation
ETS	European Emissions Trading Scheme
EWEA	European Wind Energy Association
FBR	fast breeder reactor
FDP	Freie Demokratische Partei (Free Democratic Party [Germany])
FIT	feed-in tariff
GE	General Electric
GHGs	greenhouse gases
GW	gigawatt
GWEC	Global Wind Energy Council
IEA	International Energy Agency
JPEA	Japan Photovoltaic Energy Association
JWPA	Japan Wind Power Association
LDP	Liberal Democratic Party (Japan)
LNG	liquid natural gas
mb/d	million barrels per day
MEP	Ministry of Environmental Protection (China)
METI	Ministry of Economy, Trade, and Industry (Japan)
MITI	Ministry of International Trade and Industry (Japan)
MOE	Ministry of the Environment (Japan, Norway)
MOF	Ministry of Finance (China, Japan)
MOFA	Ministry of Foreign Affairs (Japan)
MOPE	Ministry of Petroleum and Energy (Norway)
MOST	Ministry of Science and Technology (China)
MW	megawatt
NCPA	Norwegian Climate and Pollution Agency
NCS	Norwegian Continental Shelf
NDRC	National Development and Reform Commission (China)
NEA	National Energy Administration (China)
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NHO	Næringslivets Hovedorganisasjon (Confederation of Norwegian Enterprise)
NIMBY	not in my backyard
NPD	Norwegian Petroleum Directorate
NRA	Nuclear Regulatory Agency (Japan)
NVE	Norges vassdrags- og energidirektorat (Norwegian Water Resources and Energy Directorate)

OED	Olje- og energidepartmentet (Ministry of Petroleum and Energy [Norway])
OLF	Oljeindustriens Landsforening (Norwegian Oil Industry Association)
PPP	purchasing power parities
PTC	Production Tax Credit (USA)
PV	photovoltaic
REL	Renewable Energy Law (China)
RPS	Renewable Portfolio Standard
SEIA	Solar Energy Industries Association (USA)
SERC	State Electricity Regulatory Commission (China)
SOE	state-owned enterprise
SPD	Sozialdemokratische Partei Deutschlands (Social Democratic Party of Germany)
StrEG	Stromeinspeisungsgesetz (Electricity Feed-in Law [Germany])
TEPCO	Tokyo Electric Power Company, Incorporated (Japan)
TIC	techno-institutional complex
TPES	total primary energy supply
TWh	terawatt hours
VC	venture capital
VDEW	Verband der Elektrizitätswirtschaft (The Association of Electrical Industry [Germany])
WWEA	World Wind Energy Association

1
Introduction

In 2013, Chinese President Xi Jinping declared that China will no longer sacrifice the environment for temporary economic growth (*CCICED*, 2013); a year later Premier Li Keqiang followed up by stating that China 'will resolutely declare war against pollution as we declared war against poverty' (*Guardian*, 2014a; GWEC, 2014, p.14). Whether China lives up to its promises obviously remains to be seen, but clearly environmental and energy issues now attract serious attention from very powerful political and industrial actors. In a world where oil prices, despite their recent dramatic fall, had long been stable at more than US$ 100 per barrel, where peak oil (as in the point of maximum oil production (after which it will inevitably decline)) is fast approaching, and where climate change is becoming an evermore concrete and tangible challenge, a fresh look at energy policy, and renewable energy policy in particular, is very much in order.

Chinese authorities are not alone in taking these issues seriously. (Rather, their statements reveal a somewhat belated emphasis of their importance.) Since the 2011 earthquake, tsunami and nuclear meltdown at Fukushima, both Japan and Germany have gone a long way toward ending their dependence on nuclear power. In the US, every president since Richard Nixon has concerned himself with energy security. President George W. Bush in 2006 warned that 'America is addicted to oil.' In 2010 President Barack Obama urged the US to make serious investments in clean energy rather than just surrendering the clean jobs of the future to Germany and China, and in 2014 he used the Environmental Protection Agency (EPA) to bypass a gridlocked Congress and impose stricter regulations on the power sector (in particular, the coal industry) (*EPA*, 2014b; *New York Times*, 2006; *White House*, 2010). In Denmark, the parliament has decided that by 2050 the Danish energy system will be fossil free (Lund et al., 2013). And in Norway, former Prime Minister Jens Stoltenberg in his 2007 New Year's speech somewhat pompously labeled the development of Carbon Capture Storage (CCS) technology as Norway's equivalent of the moon landing, and its contribution to solving the world's energy and climate problems (*VG*, 2007).

Some of these initiatives and utterances may prove to have been little more than rhetoric and lofty plans. After all, worldwide emissions have never been higher than in 2013.[1] But even lofty plans and rhetoric often provides a suggestion as to which way the wind blows, and about what stirs the public imagination. It is certainly clear that energy issues are at the forefront of the political discourse like never before. Energy security no longer just means more oil on bigger oil tankers. It means that we, to an ever greater extent, need to come up with new ways of producing energy (as well as new ways to reduce energy consumption). And preferably, the new energy alternatives need to be far less polluting than the old ones. If not, the Chinese war on pollution would be lost before it had even gotten underway, and the Danish plan to become fossil free would be nothing but fine words on glossy paper. While there is no single solution to these problems, it is very hard not to see renewable energy as one of them.

So, renewable energy must be pretty important, then? The question may seem puzzling. But the first and most obvious answer is that, in and of itself, it really is not. Out of global final energy consumption, renewable energy (not including hydro) accounts for no more than 1.2 percent (2.0 if biofuels are included), and out of all global electricity production, the wind and solar share is 3.6 percent, with 2.9 percent for wind and 0.7 for solar (see Figure 1.1).[2] These numbers increase year by

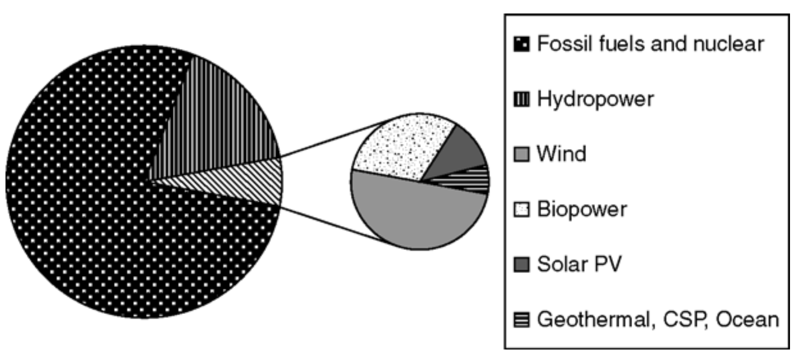

Figure 1.1 Renewable share of electricity production, 2013
Source: REN21 (2014).

year, but they are still very small, and fossil fuels provide a fairly steady 80 percent of our energy (REN21, 2014). So, why spend an entire book on something that accounts for only a little more than 1 percent of global energy consumption?

The more roundabout answer is that the world is currently facing, or in the midst of, a number of different crises. Some are immediate, some are drawn-out, and others are mainly about the future. But since 2008 we are in the midst of a financial crisis. It is the biggest economic crisis the world has faced since 1929, and it has been particularly protracted in Europe. In China, stimulating renewable energy industries – industries perceived as major growth industries of the future – was part of the Chinese government's plan for China to keep growing through the crisis, and notions of renewable industry heading a wave of green economic growth was much heard both in Europe and in the US. Second, we may be looking at an energy crisis. By all means, this is a different kind of crisis than the financial crisis and we are slowly adjusting to a world where oil is far costlier than a mere decade ago, but when the oil price started climbing, the increase was extremely abrupt, from less than $20/barrel in 2002 to $50 in 2007, before peaking at $147/barrel in 2008. It has fluctuated considerably since then, but since 2011 only rarely dipped below $100/barrel. Granted, at the time of writing, and in less than a year, the oil price has more or less halved, currently standing at around $60/barrel, analysts warning that the dip may be more than just temporary. Still, the long-term forecasts are for prices to once again increase. The International Energy Agency (IEA) (2013c) predicts $128/barrel by 2035, and before the oil price started crashing, an IMF working paper suggested as much as $180/barrel already by 2020 (Ayres, 2014). This estimate is now unlikely to be fulfilled, but it does suggest that eventually prices will inexorably start rising again.

The oil price contributes to the financial crisis in the sense that energy prices this high are undoubtedly bad for the overall economy. However, the real energy crisis is more of a drawn-out thing. Peak oil has been a concern for decades, and while it represents no immediate problem (we keep pushing it into the future), it is quite obvious that today's fossil fuel regime cannot last forever, for the simple reason that the resources will eventually exhaust (or at least dwindle to such an extent that they become exorbitantly expensive). Third, we may be looking at a climate crisis, which is another drawn-out, long-lasting crisis where the immediate impact is not particularly severe, but the long-run consequences are far-reaching. Thus, if peak oil is upon us, not only do we need to compensate dwindling reserves of fossil fuel with something else, but in order to combat global warming, this 'something' else needs to be fairly emissions-free. Thus, while renewable energy is not the answer to all our worries, first it could provide us with new growth industries, second with more energy, and third with relatively *emissions-free* energy. It could go some way to providing solutions to all three crises (obviously renewable energy technologies still have to become cheaper and more efficient). And if we look at how fast renewable energy has expanded, the prospects may not even be completely far-fetched. Since 2000, on average, wind power installations have increased by 24 percent annually, whereas PV (photovoltaic) capacity has increased by an average of 41 percent. In 2000, global wind power capacity was not even 20GW, whereas in 2014 it reached 370GW (see Figure 1.2). For solar, in 2014, capacity reached an estimated 185GW, up from a mere 1.5GW in 2000 (see Figure 1.3) (EPIA, 2014a; GWEC, 2015; REN21, 2014; *SolarServer*, 2015; WWEA, 2014).

But if all this is true, and if renewable energy can potentially be this important, why do we not just install it? Sheikh Zaki Yamani, Saudi Arabia's powerful minister of oil and mineral resources from 1962 to 1986, once famously said 'the Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil' (quoted in Aleklett, 2012, p.121). In his mind, oil would be replaced

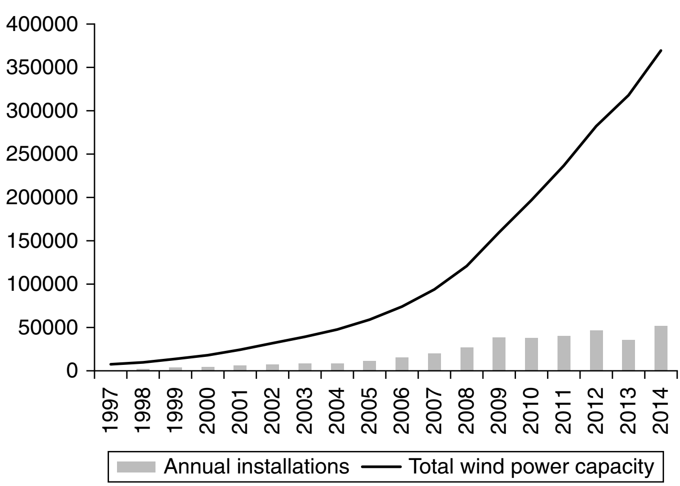

Figure 1.2 Total and annual installed wind power capacity, 1997–2014 (MW)
Sources: GWEC (2015); REN21 (2014).

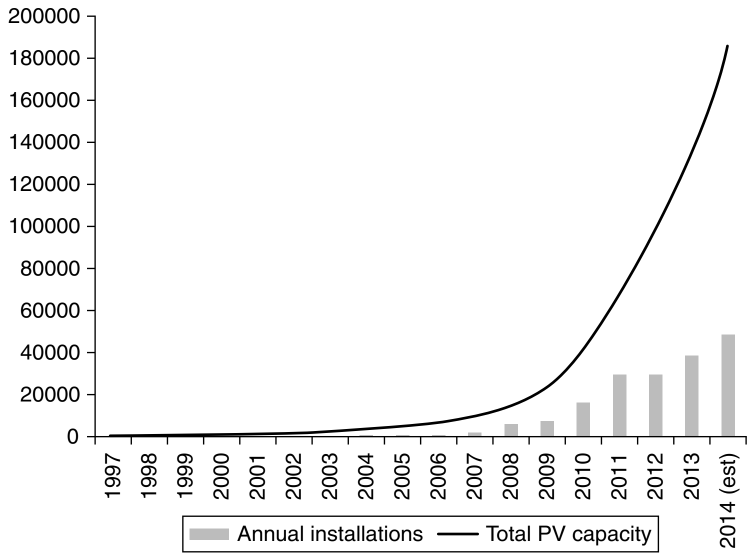

Figure 1.3 Total and annual installed solar PV capacity, 1997–2014 (MW)
Sources: REN21 (2014); *SolarServer* (2015).

by more efficient forms of energy as new and better technologies were invented, and this would occur long before the oil had been extracted. Thus, if renewable technologies were already competitive, the market mechanism by itself would guarantee that renewable energy is fed into the system in such quantities that it makes for an energy transition. One of the goals of this book is, however, to show why this is *not* so, and how in most countries the institutional setup often contains a heavy bias in the direction of fossil fuels. Thus, there is no guarantee that Sheikh Yamani is right in suggesting that this problem will take care of itself. Michael Klare's (2012b) prediction that we are instead facing a race for the planet's remaining fossil fuel resources seems equally prescient. The Oil Age may easily end exactly because we run out of oil.

In a world without learning effects, economies of scale, barriers to trade, institutions, externalities, and so on, markets might easily provide the solution. Markets would then accurately factor in the extra costs deriving from fossil fuels from emitting CO_2 and other greenhouse gases (GHGs), so that all energy industries could compete on equal terms. In such a world, the fact that fossil fuel industries have had far longer to realize economies of scale and to develop mature technologies than most rival energy industries would not be important. However, this is not the world that we live in. Economists can help us compensate for some of the disadvantages that renewable energy industries and technologies face. Carbon taxes would, for instance, go some way toward putting a price on externalities resulting from GHG-emissions. The higher the tax on carbon emissions, the more competitive renewable energy would be, and the more the markets would favor renewables over other forms of energy.

However, ultimately carbon taxes are politically determined, and as such subject to a myriad of concerns. If one country sets its carbon taxes radically higher than other countries, energy-intensive companies may flee and set up shop abroad instead. Also, high energy and electricity prices are bad for the competitiveness of the industry in general, and it is bad for the purchasing power of common people. Thus, introducing, or indeed raising, carbon taxes comes at an industrial and economic, not to say a political cost, and one that politicians are often loath to bear. Doing the right thing for the long-haul is a distinctly bad political strategy if it costs you the next election.

But the lack of a global carbon tax set at an appropriately high level is only one of many reasons why renewable energy is not just replacing fossil fuels overnight. There are other structural constraints as well. Let us breeze easily past the more obvious ones: renewable energy has had far less time than fossil fuels to mature its technologies. Thus, in terms of learning effects, we expect technological progress in renewable energy to be faster than progress in established energy technologies. And in terms of economies of scale, the old and trusted industries have had far more time to realize these than have renewable industries.

The slightly more subtle bias is a political one. Institutional theory tells us that institutions create stability. They are the rules of the game. They lead to path-dependencies, and they act as bulwarks against radical change (e.g. March and Olsen, 1989; North, 1990; Olson, 1982). Consequently, institutional change also tends to occur at a far more glacial pace than technological change. New and upcoming industries frequently have different needs than established ones – in terms of knowledge and education, capital, linkages between academia, government and industry, patenting systems, and so on. The degrees to which these needs are met are crucial. A national system of political economy may be a good fit for one type of technologies and industries, but a distinctly bad one for other (and often rival) technologies and industries (e.g. Freeman and Perez, 1988; Gilpin, 1996; Nelson, 1995; Unruh, 2000). Quoting Gilpin:

> ...a society can become locked into economic practices and institutions that in the past were congruent with successful innovation but which are no longer congruent in the changed circumstances. Powerful vested interests resist change, and it is very difficult to convince a society that what has worked so well in the past may not work in an unknown future. Thus, a national system of political economy that was most 'fit' and efficient in one era of technology and market demand is very likely to be 'unfit' in a succeeding age of new technologies and new demands. (1996, p.413)

Thus, if the institutional system heavily favors old and established energy actors over new and promising, but ultimately vulnerable renewable energy actors, then this is something that markets will not pick up on. And so, if renewable energy is among the solutions for the future, energy-wise, industry-wise and climate-wise, the above points represent just a few reasons why markets do not automatically allocate enough resources to renewables. This also suggests why it is necessary to bring in the social sciences. The naïve take on renewable energy would be to simply think of this as a technological challenge, solved by natural scientists and engineers, letting technological progress run its course, and then within hopefully not too long, renewable energy technologies would be so efficient and sophisticated that they can compete on equal terms with fossil fuels.

This is, however, a book on the *political economy* of renewable energy, suggesting that politics and economics are crucial to understanding renewable energy. Obviously this does not mean forgetting that there is a heavy technological component to the rise (or the failure) of renewable energy. Compared to other and more established energy technologies, renewable technologies still have a lot of maturing left before they are anywhere near revolutionizing the world's energy supply. But this takes nothing away from the fact that in addition to technological constraints, there are economic and political constraints affecting the prospects of renewable energy. Few areas are more cross-disciplinary than energy policy.

It is impossible to understand energy policy without understanding the linkages between the technological, the economic and the political. When renewable energy is *not* implemented in a country, this might be for technological reasons. But if we compare the most developed countries in the world, their ability to solve and work around technological obstacles is more or less the same, and so if one country manages to solve its technological problems, most others could follow suit. Then, there might be economic problems, typically as in renewables being too expensive, but many of the economic constraints faced by different countries also resemble each other. And then there are the political problems, and the political constraints, which are often the hardest to penetrate – because politics regularly operates according to a different logic, one that involves stakeholders, vested interests, institutions and institutional biases, as well as path-dependencies and inherited organizational and institutional cultures and quirks that are country-specific and where the experiences of one country cannot always be transferred to any other.

Renewables or bust?

So, are there no realistic or credible alternatives to renewable energy? Is renewable energy so important because it is the only current answer? The answer is not at all straightforward, but let us look at some of the alternatives.

Let us start with the default solution, which is simply more of the same. Granted, whether or not peak oil is upon us, there is no immediate danger. The world's proved oil reserves have kept on increasing, especially if we also take unconventional sources into account, and the current drop in oil prices strongly suggests that the world is not running out of oil overnight. Instead, it is rather a matter of how eagerly we pursue the remaining resources, open up new areas for exploration, the extent to which new technologies can help us in exploiting resources that in the past used to be technologically unfeasible, and the extent to which new technologies can help us to extract a higher percentage of petroleum from existing wells. So, to an authority such as Daniel Yergin (2011) – co-founder and chairman of Cambridge Energy Research Associates and a Pulitzer Prize winner – the world is still awash in oil. We may be approaching a production plateau, but no peak. Reserves have never been greater, and pretty much the same goes for production levels (Yergin, 2011, p.239)![3]

Others are not equally sanguine. Michael Klare (2012a, 2014) – professor at Hampshire College and the author of a number of highly influential books on oil and energy – forcefully states that while it is technically true that we are awash in oil, the days of '*easy* oil' are long gone. Over the next 25 years, 'easy oil' fields will lose 75 percent of their productive capacity.[4] Shale gas, breakthroughs in fracking, deep-sea drilling, and Arctic oil may prolong the petroleum age. But if the future were to be still fueled by petroleum, every pretense of this being a cheap and abundant source of energy must surely be abandoned. Scarce and expensive energy will also keep jeopardizing the growth prospects of the world economy.

Peak oil has been predicted before. In 1956, Marion King Hubbert, who coined the term, predicted that US oil production would peak between 1965 and 1970, in 1962 he suggested that world oil production would peak in 2000 and in 1974 that the peak would be in 1995. Numerous others have also engaged in this activity, but so far, the doomsayers have been proven wrong. Production today is twice of what it was in 1970 and more than four times of what it was in 1960. The present consensus times peak oil to some time between 2010 and 2030, with oil production definitely declining after 2050 (Aleklett, 2012; Chapman, 2014; Sorrell et al., 2010). Yet, while reiterating the lack of any immediate danger, demand for oil does keep increasing, and very few new giant fields are discovered anymore. It is not that the rate at which we find new oil fields has dropped dramatically, but the size of these fields are now significantly smaller than a few decades ago. In 1960, a record 60 new gigabarrels of oil were discovered. By 2010, this had dropped to only ten. Since 1980, oil consumption has exceeded oil discoveries every year except for two. The world presently consumes approximately 87 million barrels of oil per day (mb/d). Demand is projected to rise to 101mb/d by 2035, at which time *conventional* crude oil production may have fallen to 65mb/d. The in-between volume will have to be covered for by unconventional oil and natural gas liquids (Aleklett, 2012; Ayres, 2014; Energimyndigheten, 2006; IEA, 2013c).

Can this be done? After years of strong growth, these are somewhat testing times for renewable energy, its prospects not as certain as only a few years ago. Part of the reason for this is the breakthrough in fracking that in the US has led to a potential revolution in shale gas and tight oil. This could be a game-changer. In 2012, the IEA confidently predicted that by 2020 the US will be the world's largest petroleum producer, overtaking Saudi Arabia and becoming a net petroleum exporter. This is a major turn of event. In 2013, the US surpassed Russia as the world's largest *energy* producer (Blackwill and O'Sullivan, 2014).

Thus, in the US, tight oil production increased 18-fold between 2007 and 2012, almost doubling overall US oil production, whereas shale beds account for more than 50 percent of natural gas, up from only 5 percent a few years ago. The fresh supply of shale gas led to US gas prices dropping from $12/million Btu in 2009 to less than $2 in 2012. In the US, the immediate consequence has been for coal to be substituted by natural gas, which has reduced GHG-emissions in the US. The other consequence is to render renewable energy far less competitive. In 2012, which was a breakthrough year for US shale, shale gas led to a decrease in renewable US energy investments (EREC, 2013). The impact on natural gas prices is local, not global. In Germany the price stands at $11/million Btu, and in Japan it has been as high as $17. In other words, outside of the US, the competitive pressure on renewable energy is less. On the other hand, the US preference for natural gas over coal means that the US now ships far more of its surplus coal (US coal exports to Europe increased by 29 percent in 2012) to Europe, where coal prices immediately dropped by a third. Thus, in Europe, coal has replaced liquid natural gas (LNG) (*Financial Times*, 2013), and the main reason why in Germany coal keeps *increasing* its share of energy and electricity production at the expense of natural gas is that the shale revolution makes coal less desirable in the US – where its relative price has increased – but more desirable in Europe, where its relative price has fallen. Europe is now ‘an unfortunate mirror image of the US’ (*energy post*, 2014).[5]

For us, the crucial question is, however, whether or not shale can be the energy answer for the future. Is it a credible alternative to renewable energy? Does the shale revolution push any notion of peak oil into an indefinite future, or does it just breathe some extra life into an already waning energy paradigm? The answer depends very much on who you listen to. In 2012, President Barack Obama made a bold claim that the US has enough natural gas to last a hundred years. *Time* (2013), in 2013, declared that peak oil is dead. *Business Insider* (2013) stated that ‘we have slayed “peak oil” once and for all, thanks to the combination new shale oil and gas production techniques and declining fuel use.’ *The Wall Street Journal* (2012) ran a piece simply titled ‘Saudi America’, on how the US would soon become the world’s largest oil producer – if it only frees itself from the shackles of environmentalists demonizing anything that smacks of carbon energy. From the petroleum industry we hear that the US has the petroleum fracking resources of two Saudi Arabias. And both the IEA and the US Energy Information Administration (EIA) have been very bullish about US resources, and how this could completely alter the world’s energy situation (*GlobalResearch*, 2014; Heinberg, 2013).

This bullishness is giving way to more sober assessments. IEA (2013c) now says that tight oil will have a major impact over the next decade, but not in the long term as the US will reach a plateau over the next decade. The EIA has made very drastic downward adjustments to their estimates of recoverable oil. Their current estimate for shale gas is for 24 years of supply at current rates, with other estimates as low as ten years. The main problem is that production at the wells typically drops off by 60–90 percent in the first year of production alone and 80–96 percent during the first three. Thus, merely keeping production at current levels requires evermore drilling at ever higher costs. The US can keep doing this for a while, and there is undoubtedly much life in the industry, but there is also little doubt that the industry has a vested interest in perpetuating the image of shale as the way forward and as the wonder fuel of tomorrow. US petroleum and drilling interests have very deliberately sought to urge US energy policy in the direction of shale (Ayres, 2014; Heinberg, 2013; *LMD*, 2013; *Los Angeles Times*, 2014; *Power*, 2014f).

It is also not obvious that this is a good move even for the US. The break-even point for shale gas is estimated at somewhere between $4 and $8/million Btu, and currently the industry is losing money. The top shale gas producers are taking heavy losses and have large debts, and the recent oil price fall is threatening the profitability also of a number of tight oil producers. Thus, without gas prices increasing (and possibly also the oil price), the shale revolution will be stillborn not only because the wells deplete but also because it is not profitable (EREC, 2013). Thus, this is not presently a moneymaker for the US or for the US petroleum industry. Also, for shale to be a worldwide revolution, it would have to spread to other countries. There are limited prospects within the EU. With the exception possibly of Poland and Ukraine, where reducing energy dependence on Russia is the biggest concern, Europe seems highly reluctant. European public opinion prefers renewable energy over shale and the EU Commission has noted how shale gas causes higher GHG-emissions than conventional natural gas.[6] China, which has the world's largest reserves, does indeed have a shale development plan. But there are major impediments to large-scale production. Chinese coal seams are deeper and less accessible than US seams (which have mostly been found at shallow depths), and fracking requires large amounts of water, which is a far scarcer commodity in China than in the US. Thus, China is still essentially on the fence, and production goals for 2020 have been slashed by more than 50 percent (*Economist*, 2014f; Hu and Xu, 2013; *theenergycollective*, 2014b; Wan et al., 2014; Wang et al., 2014). The jury is still very much out on the potential of shale, but even at present rates of production, shale has definitely made an impact. If it were to be a true energy revolution, this would be bad news for renewable energy, even if so far in the US, it has led mostly to the substitution of coal.

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 and has dwindled in popularity since Chernobyl. And as the world was again starting to feel safe for nuclear, Fukushima happened. Fukushima led to Germany giving up on nuclear overnight and to Japan losing its entire nuclear power capacity. However, for Japan, the absence of nuclear, and the only gradual expansion of renewables, for all practical purposes makes it impossible to fulfill Kyoto commitments as the energy gap is made up for by massive LNG imports, and for Germany, renewable energy is just about capable of compensating for the power loss from nuclear, but this also means that the fossil fuel share of energy and electricity production remains more or less unchanged. In the meantime, other countries are increasing their nuclear capacity. Worldwide 62 new reactors are built, most in China, which is adding 26 reactors to its present 16. Thus, both for energy and climate reasons, nuclear will stay with us. Indeed, Fukushima has showed 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 above 10 percent by 2030, thus what we are witnessing is no nuclear energy revolution. Actually, renewable energy in China expands faster. In 2012, total wind power output for the first time exceeded nuclear power output (Andrews-Speed, 2012, p.50; REN21, 2013a; *TU*, 2012a). Thus, while some countries are expanding their nuclear capacity, nuclear is not the answer to our questions. The IEA (2013c) expects nuclear power to maintain its share of electricity generation worldwide, which means around 12 percent, but not go beyond that. Also, if nuclear were to start expanding at a rate that would actually make a major difference to the world's energy supply, then it is not apparent that our deposits of uranium would last much longer than the petroleum.

Finally, and most depressingly from a climate perspective, coal keeps expanding. This is mostly because of China, which in 2011 accounted for 87 percent of the world's increase in coal consumption, and whose demand for coal is expected to continue to rise until reaching a plateau no sooner than 2025. But as mentioned, because of shale, coal is on the rise in Germany as well. Granted, this rise is not expected to be permanent, but it does bear witness of an industry that is not prepared to give in. The coal industry is also among the most powerful vested interests in the US. Thus, in terms of global primary energy demand, by 2035, the share of coal will not have changed much. In its 'New policies' scenario, the IEA (2012b) suggests that coal's share will fall from 28 to 25 percent. However, in their default scenario, it instead increases to almost 30 percent. Carbon Capture Storage could be a solution. However, the IEA (2013c) reckons that by 2035 only 1 percent of all fossil fuel fired power plants will be CCS-equipped. Despite the deleterious effects of coal on GHG-emissions, unless policies radically change, there will be no major phase-out in the near future.

Is renewable energy the answer? And, if so, what exactly is it the answer to? According to all predictions and projections, energy consumption will keep rising. No doubt, technological progress will also result in major energy efficiency improvements, but, so far, there is little indication that this will lead to energy consumption actually falling. Thus, it is not very controversial to expect that we will only need more energy. Conventional oil and gas will hardly be able to expand much further. Even if no peak oil is imminent, petroleum extraction will drop rather than increase. Shale gas and tight oil may pick up some of the slack, and the potential from Arctic oil and deep-sea drilling is hard to estimate. But with both the IEA and the EIA holding far more sober assessments of the prospects of shale gas and tight oil than only a year ago, and since Arctic oil and deep-sea drilling will be costly no matter, it is hard to see much actual *growth* in energy production stemming from petroleum. Based on present knowledge, it is also hard to see nuclear ever getting the renaissance that will make it the answer to our energy prayers if not for major breakthroughs in thorium. And, despite technological improvements and the potential introduction of CCS to coal power plants, most policymakers are hesitant about coal as the energy solution of the future. Even coal with CCS is not an environmentally friendly solution. Retrofitted to existing plants it would obviously be an improvement compared to the status quo, but *new* coal plants with CCS would not be.

This leaves us with renewable energy. Granted, as compared to the 87mb/d of oil that we currently consume, the amount of power produced by wind is the equivalent of roughly 2mb/d and by PV only 0.4mb/d (Jaffe and Morse, 2013). When President George W. Bush talked about the American oil addiction, his major solution was biofuels. But most likely biofuels will never be more than a small player, especially as the consequence of increasing our production of biofuel would seriously take away from our ability to produce food. Turning the whole crop of US maize into biofuels would, for instance, not amount to more than 5 percent of US oil demand (Chapman, 2014). Thus, policymakers are far less sanguine about the prospects for biofuel than only a decade ago. And the oldest of all renewable energy technologies, hydropower, still has much life left in it, but beyond developing countries, the potential for expansion seems limited. Geothermal, wave energy, and other types of renewable energy have considerable potential, but, at present, these rely on far more immature technologies than solar and wind. For the foreseeable future, and as long as no wonder technology suddenly appears out of the blue, solar and wind power will be the backbone of the renewable energy drive, and they will be the energy sources most likely to have the ability to provide a boost to this world's energy production. Can they transform the world of energy? Or are they doomed to remain bit players in a world that stubbornly persists with fossil fuels? Within the world of renewable energy we see both success stories and relative failures. This book is an attempt to distinguish the successes from the failures. Why did some countries pursue renewable energy with so much more enthusiasm and dedication than others? What has been the key to their success? While the answer may not directly tell us whether or not the world's energy structure can or will be transformed, it will say something about whether or not some of the leading economies in the world (as well as some smaller ones) will forge ahead and lead this process, or whether the prospects for a worldwide energy transformation are rather gloomier.

The story, the argument, and vested interests

In order to shed light on why renewable energy is promoted by some and not by others, what we need is an understanding of the underlying drivers of the political economy. Thus, when in this book I look at the renewable energy policies of six countries – Japan, China, the US, Germany, Denmark, and Norway – this is not supposed to be a book only about six specific countries. Rather, the general aim is to say something systematic about the political economy underpinning the growth (or the lack thereof) of renewable energy.

Thus, what this is *not* is a book on present energy and/or environmental policies in a select group of countries, or a review of policy changes over a certain number of years. This already exists. By all means, in this book you will obviously find information about concrete policy actions and changes. However, what to a far greater degree is missing from the literature is information on the more general political economy of renewable energy policy, for two reasons, I think. First, the literature on renewable energy has been dominated by natural scientists. Obviously, one should not be surprised that natural scientists have a better grasp of technological matters than social scientists, but it inevitably leads to a discourse centered on technical problem-solving, ignoring the economic and political aspects of renewable energy policymaking. Second, to the extent that social scientists *have* focused on energy issues and renewable energy, their accounts have tended very much toward the description of policy measures and policy initiatives. Instead, in order to gain a firm grasp of the underlying drivers of renewables, we need to recognize that today few areas are more cross-disciplinary, and that it is impossible to understand energy policy without understanding the linkages between the technological, the economic, and the political.

Thus, this is the story of a Japan where energy policy has been gridlocked by strong vested interests for four decades, but where Fukushima has forced the most serious re-think to energy policy for that entire time and overnight has led to a booming solar PV market. It is also a story of a country that both before and after Fukushima has systematically opted for PV to the detriment of wind power, which has been sorely neglected. It is also the story of a China where the renewable expansion has been faster than anywhere else, and where the sky seemingly is the limit, but where there are still potential clouds on the horizon, albeit clouds that by many are ignored because impressive growth is keeping everyone happy for as long as growth persists. It is the story of a US which has endured more, as well as more pronounced, policy swings over the past four decades than any of the other countries, and where renewable energy policy to a very small extent has been institutionalized. The US story is also about a legislature that gridlocks easily and which has readily fallen prey to the influence of vested interests, making it difficult to pursue more than incremental change. Germany is the story of a country where a very robust social and political consensus on environmental protection, nuclear phase-out and renewable energy early on led to the development of a strong renewable energy coalition, which enabled such a rapid phase-in of renewables that no country has so far installed more solar PV. But it is also the story of a country that was so successful in phasing-in renewables that eventually subsidies became so expensive that the entire renewable support structure has had to be restructured. Thus, the German story now has a more open-ended future than most would have foreseen only a few years ago. This is also the story of Denmark, which grew to become maybe *the* iconic wind power country. With the greatest wind turbine density in the world and the world's biggest wind turbine manufacturer in Vestas, Denmark has had one of the most stable support frameworks for renewable energy and derives more of its electricity from wind than any other major country. And, finally, it is the story of Norway, which unlike the five others, is an energy-exporter rather than an importer. Norway is the world's third largest energy-exporter and in addition to petroleum has an abundance of hydropower. Thus, the Norwegian story is a story about how renewable energy has fared in a country that is highly energy-secure and has very strong vested interests with respect to petroleum extraction. Consequently, it is also a story about a country where wind and solar power have so far been sideshows and window-dressing.

On a more general level, this is the story about the political economy of renewable energy, and about why some countries so much more enthusiastically pursue renewables than others. One default expectation would be to simply assume that the ambitiousness of a country's renewable energy policies mirrors the seriousness of its energy problems. Thus, countries with unsolved energy problems (or an abundance of renewable energy resources) ought to have more ambitious policies (e.g. Eikeland and Sæverud, 2007). This book, however, suggests that there is far more to the story.

Thus, this book suggests that this is also the story about how vested interests bias political decision-making and wrest away from the state the autonomy to independently pursue policy. Strong vested interests for instance make it difficult for a Norway which has become wealthy by exporting petroleum to change its energy-political course. Decisions are often biased in the direction of the most powerful interests. Likewise, for a country that is scarce in energy resources, and with only weak vested energy interests, it is far easier to initiate renewable energy programs and support structures, as there are far fewer interests to oppose this.

Why are vested interests a problem? Here I suggest two answers: one immediate and one more long term and fundamental. The short and immediate answer is derived from the economic historian Joel Mokyr (1990). Through history, vested interests have always protected themselves by seeking to block structural change, technological progress, the rise of challenger industries, and so on. In his book *Lever of Riches*, Mokyr outlines three mechanisms through which this has historically happened. First, there is outright physical resistance against new technology, as in strikes, riots, and even the destruction of new machinery. Second, opposition has taken the form of laws and regulations restricting the implementation of new technology and erecting barriers of entry, such as guild systems, trade unions, labor unions, lobby groups and state monopolies. And third, vested interests have shielded themselves against competition and change by pushing through protection and favorable treatment, such as tariffs and subsidies.

Thus, vested interests have a number of ways in which they, for all practical purposes, block the rise of rival industries – which in this book means renewable energy industries. Renewable energy industries and technologies have to rise against an economic and industrial backdrop dominated by old and influential energy interests. Granted, the old and established interests may not actively seek to make life hard for renewables; however, as they fight for their own interests, for regulations, subsidies, favorable institutional arrangements, and so on, they often invariably do this at the expense of renewable energy. As Gilpin (1996) makes clear, new and upcoming industries frequently have different requirements than the old and established industries, and thus the needs of coal, petroleum, or nuclear often come at the expense of the needs of renewables.

The second answer is more fundamental and centers on what it is that fuels the world economy. At the core of economic growth lies technological progress.[7] True, there are many types of economic growth. Thus, privileging growth based on technological progress does not mean that other types are unimportant. To return to Mokyr (1990), Solovian (after the US economist Robert Solow) growth is investment-led. This is the kind of growth that we get whenever the capital stock accumulates faster than the labor force. Smithian (after Adam Smith) growth is based on commercial expansion, or gains from trade – a more specialized division of labor leads to productivity growth. And third, there is growth based on scale or size effects. Finally, growth based on increases in the stock of human knowledge, innovation, and technological progress – or Schumpeterian growth (after the Austrian economist Joseph Schumpeter) – is, however, different in one signal way, namely in that it does not lead to diminishing returns. Investments, trade, and scale are all important, but you do come to a certain point where the investment rate for all practical purposes cannot be raised much higher, where world trade cannot be made much freer, markets cannot grow much bigger, where larger scale does not provide much of an extra benefit, and where further specialization cannot grow much more extreme; in other words, where the extra effort yields very small extra gains, or diminishing returns. With technological progress this is not so. One could, of course, conceive of a world in which technological progress came to a halt because there was essentially nothing left to invent. If so, technological progress would experience diminishing returns as well. However, there is no indication that this is happening. As long as technological progress occurs, and for as long as mankind keeps inventing, no diminishing returns will set in. Britain, and in general the Western world, saw growth slowly accelerate from the late 18th century onward as a consequence of industrialization, and from technological progress feeding on and reinforcing further progress, with innovation leading to more innovation. Trade, markets, and the division of labor were obviously important, but what revolutionized the way in which the world economy works, and which led to steadily increasing growth rates, was the new and unprecedented speed of technological change. Thus, if Schumpeterian growth were to slow down – if the future were to be a future in which technological progress came to a stop – the growth engine of the world economy would also grind to a halt.

What this also means in terms of our roundabout and long-term answer to why vested interests is a problem is that this is a story about structural change. Technological progress is the main driver of structural economic change. Structural change is essential for long-term growth and development. In one sense this is utterly trivial. Without it, we would all still be hunter-gatherers, or farmers and fishermen, or industrial workers. The industries that power the world economy of today are not the ones that did the job two centuries ago. It would be naïve indeed to expect the cotton textiles industry of the early industrial revolution to still be the primary driver of growth today. Similarly, structural change within the energy sector means that there are few similarities between the energy technologies that power our present-day industries and those of the early Industrial Revolution.

In another sense, it is not at all trivial. Structural change is what makes a country leap from one economic trajectory to another. It typically stems from breakthrough technological change, resulting in the rise of new industries that eventually end up serving as the growth engine of the economy for decades ahead. In textbook economic theory, whether you make a billion dollars from microchips or from potato chips makes no difference. The stimulus to the economy is the same. If instead you believe in the importance of structural change, it *does* make a difference. Making a billion from microchips is far better, because it provides productivity improvements to a whole host of different industries and gives rise to entirely new economic activities. This is what produces growth, not just in the present, but in the long run.

The world has gone through several such industries, and a number of successive waves of industrial revolutions. Empirically they have lasted for 50–60 years before saturating and giving way to new waves of growth based on new growth industries. Different scholars tell different versions of the story, but the basic elements remain the same. Thus, the economic history of the world can be described as one of core industries based on new and generic technologies serving as engines of economic growth during different historical epochs, starting with cotton textiles in the late 18th century, iron in the early 19th century, chemicals in the late 19th century, consumer durables in the early 20th century, and finally industries based on information and communication technologies (Freeman and Perez, 1988; Modelski and Thompson, 1996). The transition between these waves is, however, often not smooth. The waves are driven by the growth of one or a few leading industries. These industries first rise from obscurity to economic prosperity over a fairly short period of time, then mature, and toward the end of the product cycle they saturate, as it becomes ever harder to find new avenues of growth. As they saturate, the world economy drifts into a structural depression that is ultimately only resolved when new (generic) growth industries provide the economy with a new industrial engine. Paraphrasing Schumpeter, the world economy goes through 'waves of creative destruction' (Schumpeter, 1942; 1983). Depression destroys old firms and industries, but it also leads to the creation of new ones.

But as suggested above, creative destruction does not necessarily happen by itself. Instead, in any economy, there are strong forces that seek to prevent structural change and preserve the status quo. The logic is not particularly complicated, and can be found in, for instance, Mancur Olson (1982). As an economic sector becomes economically prosperous, it typically also becomes politically more influential, securing arrangements and institutions that are beneficial to itself rather than to the economy at large. Thus, institutional stability leads to institutional rigidity when vested interests attempt to preserve the institutional status quo that worked so well for them in the past. The more a country depends on one or a few industrial clusters, and the greater their dominance, the more likely that the state grants them the institutions and the arrangements that they desire. If the economy is controlled by vested interests, it loses its ability to change, adapt, and shift the status quo. Thus, when industrial and structural change does not happen by itself, despite the availability of new technologies, it is because of a whole vested interest *structure* protecting and sheltering the existing actors of the system.[8] There is no such thing as a level playing field. Politically, economically, and institutionally the established actors hold all the advantages.

Thus, new industries often find themselves constrained by vested interests using their influence to sway policy decisions in their favor. This is not such a big problem in an economy that is open to structural change and where technological progress is allowed to persist. But when the process of creative destruction is blocked, this inevitably leads to the silting up of institutional rigidities in the political economy. As a consequence, new and vulnerable industries easily end up in a situation where they are blocked by a political and economic structure that favors the old and established actors of the system. For new industries to rise in the presence of long-established and powerful rivals, they will need some form of backing.

By now, this long and roundabout answer is hopefully making the importance of vested interests a little clearer. These are processes that have taken place at least since the start of the Industrial Revolution (probably longer), and will keep materializing, pretty much irrespective of the industry. Now, if we move our focus away from industry and toward energy instead, we immediately see that the energy history of the world resembles the industrial history, with energy transformations mirroring the structural changes in the industrial economy. For at least the past quarter of a millennium there has been a symbiosis between energy and industry. There is a strong and well-documented correlation between energy and long-term economic growth and development (Ayres, 2006, 2014; Freeman and Perez, 1988; Smil, 1994, 2003). There is little doubt that steam power, electricity, and oil have been essential to long-term growth processes. Industrial waves would not have appeared if they had not been supported and accompanied by the discovery and rapid exploitation of a new source of abundant energy – a new resource. And through technological progress, this resource has then rapidly become more exploitable and a lot cheaper. Without new sources of energy, structural change and renewed growth in core industries would have been more or less impossible. Equally importantly, without technological change and industrial progress, there would have been little pressure to find and develop new sources of energy.

Thus, the early industrial revolution was powered by water, which then gave way to coal and steam power. Electricity revolutionized the world of energy from the late 19th century onward, and since the early 20th century, petroleum has been the life-blood of the world economy. Nuclear power was a stillborn energy transformation. Many thought of nuclear as the new miracle energy of the post-war era, but a number of accidents – Chernobyl, in particular – and problems with the storage of nuclear waste have confined nuclear power to no more than 5 percent of the world's energy supply. And the latest and most tentative and potential of all energy transformations is the one that we still have ahead of us, a low-carbon transformation entailing a shift away from the current fossil fuel paradigm and toward something based instead on renewable energy.

Such a transformation would be truly momentous, and the forces working against it are among the most powerful and influential that any new industry has probably ever faced. Energy companies are the world's biggest industrial giants. Of the world's ten largest companies (total revenue), five are fossil fuel providers, one is an electricity company, two are carmakers, and one is a mining company (*Fortune*, 2014).[9] These are companies that wield enormous political influence, companies that invariably have the policymakers' ear, and companies that have had the necessary time and resources to secure for themselves favorable institutional setups and regulatory arrangements. As these are old and mature industries and technologies, typically the kind of innovation that flows from these is incremental rather than transformational and disruptive. Very often it feels like the 'safe' choice for policymakers to offer continued public innovation support for mature technologies and industries. But that also means that governments invariably send out the signal to investors that capital will keep accruing to old technologies rather than to new basic innovations and potential transformational and disruptive technologies. And so, in so many countries, there is a strong institutional bias in favor of the present energy structure, based on fossil fuels (and sometimes nuclear) and on big, centralized energy utilities distributing electric power to a vast number of industries and households. Unruh (2000) labels these *techno-institutional complexes* (TICs). They are large technological systems embedded through feedback loops between technological infrastructure and institutions. Once locked in, they are not easily replaced. Today's petroleum companies are the biggest industrial giants on the planet, part of a TIC that perpetuates a fossil fuel based infrastructure, exacerbated by government subsidies and institutions, and resulting in what he calls a 'carbon lock-in'. It typically takes political action beyond mere market mechanisms to displace a TIC and implement a new energy structure.

If renewable energy were to emerge as the energy of the future, replacing fossil fuels, this would constitute one of the biggest structural changes ever in terms of energy production and supply. Its rise is in no way guaranteed. Especially since for it to happen, it would have to rise against a locked-in energy structure populated by the world's biggest industrial giants, actors that have had years to influence the system that they are an intrinsic part of. This means that whether renewable energy is the next big wave or not, what we need to analyze are the vested interest structures of countries, their path-dependencies and the extent to which they are seriously and actively pursuing policies of structural change. An analysis of renewable energy that takes the international political economy as its starting point thus has to do two things: It has to take into account the linkages between technology, economics and politics, explaining the rise (or the absence) of renewables in terms of the underlying dynamics of the political economy of a country. But it also has to realize that a proper treatment of renewables means inscribing it in a political economy tradition focusing on structural change, with renewables as only one of, through history, a series of industries and/or energy providers that have had transformational potential on the world economy.

Vested interests are obviously not the sole valid vantage point for an analysis of the political economy of renewable energy. Clearly, a number of factors affect the chances of renewable energy. But by focusing on vested interests, or on vested interest structures, what we have is an angle that points us in a very specific theoretical direction, but without ever becoming a theoretical straitjacket. It hones in on certain aspects of the political economy worth analyzing, but still the notion is empirically open to the extent that it lets us look at institutions (through which vested interests often operate), different economic and political actors, interest groups, the political and economic discourse, and so on. In other words, much of the work has to be done inductively, as in investigating the extent to which political elites have been receptive to the needs of renewable energy, or if these industries have instead been at the mercy of policies designed to protect the interests of older and more established energy interests against a change in the status quo. And it has to be done inductively as in mapping the relevant interest groups in each country and extent to which they were successful in influencing policy. This also means that the theoretical framework of this book can easily be adapted to the specific circumstances of individual countries, and it allows us to respect the fact that there may be major country-specific variations in renewable energy policies that can only be understood by studying that country more closely.[10]

The case for renewables and the state of the renewable realm

The chapters in the book reveal the stories of Japan, China, the US, Germany, Denmark and Norway. All of the chapters contain quite a few numbers and statistics, as in how much wind and solar power has been installed, how rapid growth has been, and so on. While the story I am telling is not primarily a quantitative one, descriptive statistics obviously still provide us with important clues as to how ambitiously a country is promoting renewable energy. Thus, in this chapter I am pulling some of these facts and figures together. It may disrupt the flow of the story, but there should be at least one place in the book where the reader can fairly easily get a quick overview and some hard and fast knowledge of the status of renewable energy rather than having to sift through every specific country chapter, looking for the same information.

Let us start by saying that there are a number of reasons why renewable energy has major growth potential. It is obviously hard to know for sure if it will constitute *the* growth wave of the future. This is a story of Schumpeterian growth, and Joseph Schumpeter himself – maybe as a result of his not particularly happy memories as finance minister of Austria in 1919 – was inherently skeptical about the ability of politicians to pick industrial winners (McCraw, 2007). To Schumpeter, politics too often became business, with politicians essentially reduced to utility-maximizing political entrepreneurs searching for 'policy innovations' to satisfy particular interest groups and voters, rather than working for the country as a whole. Trying to win the political game, so as to remain in power, becomes priority number one.

While Schumpeter's skepticism against picking winners was a healthy one, there are, however, some things that we can say about the future with quite a lot of certainty. And so, whether renewable energy constitutes the next big wave or not, whether it will replace fossil fuels or not, and whether or not it leads to anything resembling an energy transformation, it certainly constitutes a cluster of highly interesting and promising industries that are bound to have decades of technological progress and prowess ahead of them. There are a number of reasons for this, but most obviously and fundamentally, for the first time in human history, we are starting to bump up against the planet's physical limits. True, environmental problems have been serious and commonplace in the past too (such as the London smog), but these problems were rarely more than regional, and could always be solved in one way or another (e.g. by building taller chimneys). But our problems are now becoming global. This has manifested itself in two very concrete ways: (1) Oil prices have skyrocketed (despite their recent drop), and (2) human-induced global warming has become an accepted scientific fact. While the attempts at creating frameworks to replace the Kyoto Protocol have been distinctly underwhelming, one would assume that domestic and international framework conditions are likely to yield more rather than less stringent regulations on polluting industries. And that increased renewable energy production will be part of the effort. For fairly obvious reasons, industries that can provide energy without releasing greenhouse gases and industries that reduce the energy consumption should only become more competitive.

In the short term, renewable energy will not replace fossil fuels. This would require growth on an unprecedented scale over a much extended time span. In addition, neither sun, wind (apart from under very favorable conditions), nor other types of renewables bar hydro, are able to compete on price with fossil fuels, yet. While fossil fuel prices are more likely to increase than to drop, chances are that renewable energy still has a long way to go before it can claim to be either cheap or abundant.

That said, there is an abundance of evidence testifying to the strong growth of renewables. While starting from a very small base (1.2 percent of global final energy and 3.6 percent of electricity production as of 2013), growth figures are impressive. As mentioned earlier, wind power capacity has grown by an average of 24 percent annually since 2000 (although slowing down), and solar PV by more than 40 percent. Over the past eight years, PV has grown by more than 50 percent a year. So, for a while, driven at least partially by the massive fall in costs for PV cells and modules, PV has seen extreme growth. For the past few years roughly half or more of the new electric capacity installed worldwide has come from renewable energy (in 2013, 56 percent of the net additions to global power capacity were renewable). The EU is the front-runner. Here, in 2013, for the sixth year running, renewable energy represented more than 50 percent of new electric capacity. In 2013, the figure was as high as 72 percent. Compare this to only a decade ago, when fossil fuel generation accounted for more than 80 percent of annual capacity additions, and it is easy to see that while still small, in the European electricity markets, renewable energy is making major inroads. In the US as well, in 2012, approximately half of all electricity capacity additions were renewable (although not in 2013, as politics led wind power to have a particularly bad year – more on that in the US chapter (Chapter 4)). Granted, a lot of the capacity is hydropower; of the world's total renewable power capacity of approximately 1600GW (2013), hydropower accounts for more than 1000GW. Of the remaining third, as of 2014, wind power capacity is 370GW and solar an estimated 185GW.[11] Thus, wind power has by far been the more popular. However, in 2013, for the first time, more solar PV capacity (39GW) was added worldwide than wind power capacity (35GW), something which may easily continue (EPIA, 2014a; GWEC, 2015; REN21, 2013a, 2014; *SolarServer*, 2015).

China is the world leader in terms of total installed capacity – approximately 145GW of non-hydropower renewables. The US is second with 86GW and Germany third with 77GW. Japan has a little over 27GW, Denmark 5GW, and Norway less than 1GW. On wind power, Germany held the lead until being surpassed by the US in 2008, with China moving ahead of the US in 2010. At the end of 2014, Chinese capacity was listed at 115GW, the US at 66GW, and Germany at 39GW. Denmark has almost 5GW, Japan 2.8GW and Norway around 850MW (see Figures 1.4 and 1.5) (Burger, 2015; GWEC, 2015; *pv magazine*, 2014b; *SEIA*, 2015; *Vindportalen*, 2015). Between 2005 and 2010, China, for all practical purposes, doubled its capacity every year. It should, however, be added (see also the China chapter (Chapter 3)) that the Chinese figures are somewhat inflated as up to a third of the Chinese capacity is not grid-connected, and that the US actually produces more TWh of electricity from its 66GW than China does from its 115GW (AWEA, 2015b). Growth in the US has also been brisk, but characterized by violent swings. For instance, in 2012, both China and the US installed 13GW. In 2013, however, China installed 19GW, in contrast to only a little over 1GW in the US (which then returned to around 5GW

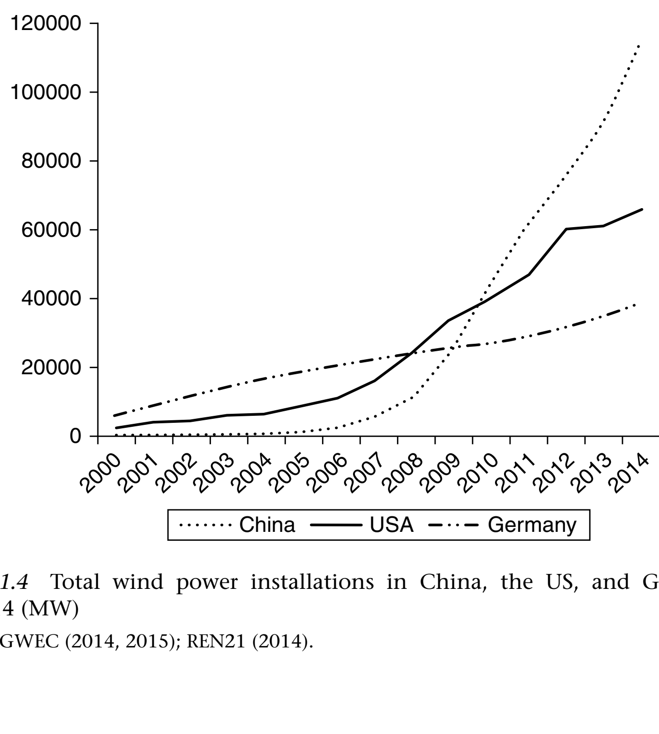

Figure 1.4 Total wind power installations in China, the US, and Germany, 2000–14 (MW)

Sources: GWEC (2014, 2015); REN21 (2014).

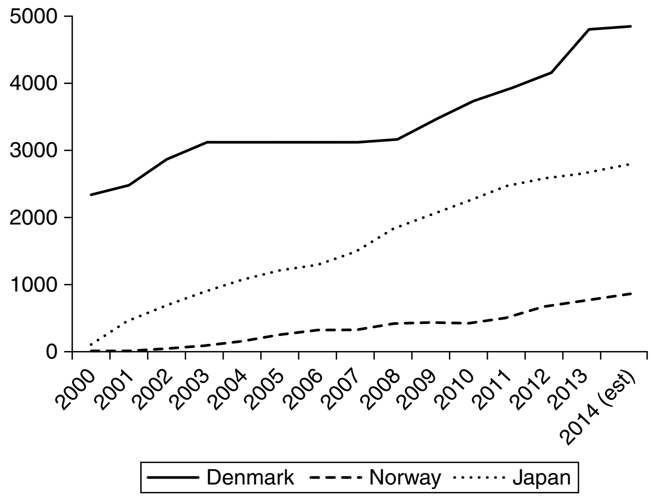

Figure 1.5 Total wind power installations in Denmark, Japan, and Norway, 2000–14 (MW)

Sources: GWEC (2014, 2015); *Vindportalen* (2015).

in 2014). Germany in comparison installs a fairly steady 2–3GW a year. Offshore wind is still tiny compared to land-based wind. As of 2014, worldwide capacity was less than 9GW, almost all of which in Europe. Great Britain accounts for more than 50 percent of this with Denmark in second place and Germany third, both with around 1GW of capacity. China, despite ambitious plans, still has less than 0.7GW, as compared to its 115GW of land-based wind (GWEC, 2015; REN21, 2014).

In solar PV, Germany is ahead of the rest in terms of installations with 38GW, due to very strong growth between 2010 and 2012, but growth which has now been reined in for cost reasons. China is second with an estimated 30GW, but with what is now the biggest solar PV market in the world, China should soon surpass Germany, maybe already in 2015, and most certainly by 2016. Japan has approximately 25GW of capacity, the US 20GW (see Figure 1.6), with Denmark a little over 0.5GW, and Norway practically nothing. Lately, the Chinese, Japanese, and US markets have all grown very strongly, and are now clearly bigger than the German market. With the energy reforms passed by the German Bundestag in 2014, its market is now restricted to 2.5GW annually. In 2014 the Japanese and Chinese markets both installed around 10GW, with the US on 8GW, but most likely growth in Japan will taper off,

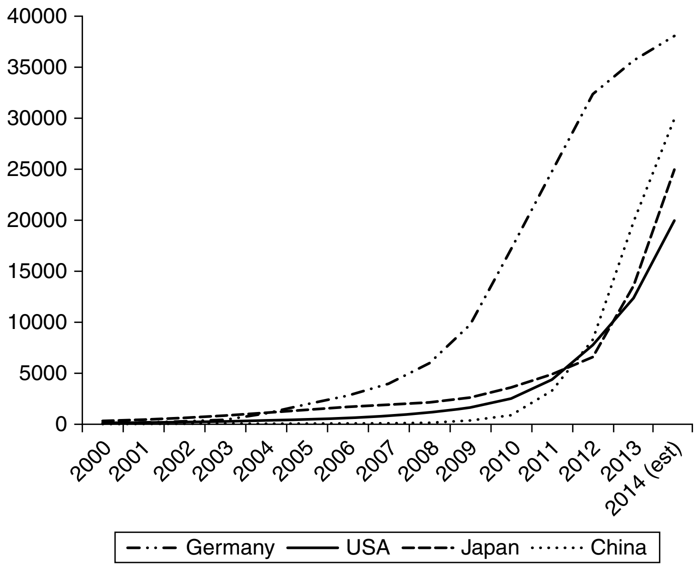

Figure 1.6 Total solar PV installations in Germany, the US, Japan, and China, 2000–14 (MW)

Sources: Burger (2015); EPIA (2014a); GWEC (2015); *pv magazine* (2014b); REN21 (2014); *SEIA*, (2015).

leaving the Chinese markets as the world's biggest (Burger, 2015; *pv magazine*, 2014b; REN21, 2014; *SEIA*, 2015).

The figures provided above testify to very strong recent Chinese growth, and most likely China will soon be the runaway leader, here as in wind. But it is obviously not fair to compare these countries only in terms of total capacity. China is more than 200 times larger than Denmark and has a population 250 times bigger, and so it would be rather odd if it was also not ahead in terms of installations. Thus, if instead we look at wind power installations per capita or per square kilometer, Denmark is the frontrunner, whereas on solar, Germany is far ahead. In per capita or per square kilometer terms, China and the US do not look equally impressive anymore.[12] (Denmark, with its rather scarce solar resources also has more solar capacity per capita and per square kilometer than China.)

Comparing the renewable share of electricity consumption is probably more relevant and more telling (see also Figure 1.7): worldwide, wind and solar account for 3.6 percent. This can be contrasted with Denmark, which in 2014 derived 39.1 percent of its electricity demand from wind

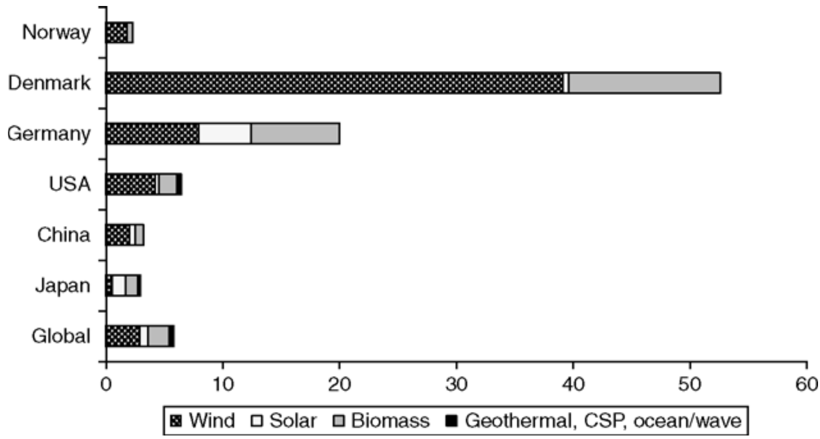

Figure 1.7 Non-hydro renewable share of electricity consumption, 2012–14 (percent)

Note: CSP = Concentrated Solar Power.

Sources: Figures and projections based on *BMWi* (2014c); DEA (2013); EIA (2014a, 2014b); *Energinet.dk* (2015); *ISEP* (2014); *METI* (2014b); NEA (2013); REN21 (2014); *SINTEF* (2012).

power alone, and where in December 2013, for the first time in any major country, wind power provided more than half the electricity for an entire month (54.8 percent).[13] Germany comes in at 20 percent. However, wind and solar only account for 12.5 percent, with almost 8 percent from wind and 4.5 from solar (the rest is biopower).[14] Still, with Denmark, Germany belongs to a group of EU countries that derive significant portions of their electricity from renewable energy. Spain, for instance, derives 21 percent from wind and Italy almost 8 percent from PV, and the EU as a whole roughly 20 percent from renewables altogether (including hydro). In contrast, Japan, China, and the US only get 3–5 percent from non-hydro renewable energy. In the US, 4 percent comes from wind, a quarter of a percent from solar and 2 percent from biopower and geothermal. In Japan, despite the late surge in solar installations, less than 2 percent is provided by solar and about half a percent from wind, with non-hydro renewables in total accounting for 3–4 percent, whereas in China, the total figure is somewhere around 2.8 percent, of which 2 percent from wind and 0.7 percent biomass. This comparison may also not be entirely fair, considering that China is a developing country, not yet having made the same major strides in energy efficiency as the others. It does, however, reveal fairly major differences between the countries. Norway is still the most different. Less than 2 percent is derived from wind power, but with hydropower accounting for 96–98 percent of all electricity, Norway is in a league completely of its own if hydropower is included in our comparisons (*BMWi*, 2014c; DEA, 2013; *EIA*, 2014a; *Energilink*, 2013; *Energinet.dk*, 2014, 2015; *ISEP*, 2014; *METI*, 2014b; NEA et al., 2014; REN21, 2014; *Vindportalen*, 2015).

If we look at investments in 'renewable power and fuels', the picture is a bit checkered as of late. The overall trend is one of massive growth, from less than $40 billion in 2004 to more than $200 billion today. But the financial crisis has led to renewable investments taking a few hits. 2009 was a lean year, but was saved by growth in Chinese investments. Beyond that, investments peaked in 2011 at $279 billion and, including large hydro, net renewable power capacity investments that year was actually $40 billion higher than net investments in fossil fuel capacity. However, since then, the road has been rockier. Investments fell by 10 percent in 2012 and another 17 percent in 2013, dropping to their lowest level since 2009 (although tentative figures suggest a bit of a rebound in 2014).[15] Some of these figures are less serious than they look, since both PV and wind power equipment has become dramatically cheaper over the past couple of years (REN21, 2012, 2014).[16] Thus, it now takes lower investment levels to install the same capacity as only a few years ago. And the general sentiment is that despite this bump in fortunes, investments should start rising again. Clean Edge (2014b), for instance, projects nearly $400 billion worth of investments by 2023.

However, these are aggregate figures, and breaking them down by country and region makes it evident that growth has become bumpier. Europe is, for instance, sharply down, the US somewhat down, and China more or less steady (see Figure 1.8). It also offers an insight into what is currently one of the biggest problems in the industry, namely boom-and-bust cycles. Booms in US investments have, for instance, had much to do with rushing to take advantage of federal support policies that are about to come to an end. And the aggregate figures hide the fact that in 2013, the US saw both a simultaneous boom in PV installations and a bust in wind power, when from the previous year installations dropped from 13GW to 1GW (GWEC, 2012, p.12; REN21, 2012, p.47). German investments peaked in 2010 at $33.7 billion, but have since then dropped for three years in a row, down to only a little more than $10 billion in 2013, and European investments in general have dropped by almost 60 percent since 2011. In 2011, Italy and Germany alone accounted for 57 percent of the new PV capacity worldwide. But the

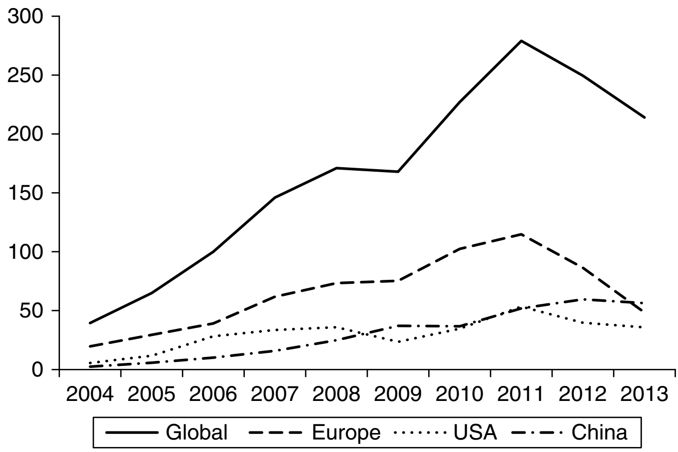

Figure 1.8 Global new investment in renewable power and fuels, 2004–13 ($ billion)

Note: Figures include biomass, geothermal and wind generation projects bigger than 1MW, all hydro projects between 1 and 50MW, all solar projects, all ocean energy projects, and all biofuel projects above one million liters of annual production capacity (REN21, 2014, p.15).

Source: REN21 (2014).

boom year of 2011 was followed by bust, as European countries experienced setbacks from setting feed-in-tariffs (FITs) too high. Italy installed more than 9GW in 2011, but only 1.5GW two years later, as the Italian and the other European markets imploded. Spain has discontinued its FIT altogether, deeming it too expensive. Germany in 2014 paid an estimated €24 billion in subsidies for all forms of renewable energy, and has now passed an energy reform which may phase the FIT out altogether by 2017 (Asano, 2012; *BMWi*, 2014a; *Reuters*, 2014b). For quite a few years, huge sums of money were spent on subsidies in what is still a financially stricken continent, and while it has often been argued that the installation of renewables is good in terms of both energy supply and in creating jobs, European countries in the midst of a heavy financial crisis have experienced not only that FITs are expensive, draining the rest of the economy of money that might have been better spent elsewhere (e.g. Marques and Fuinhas, 2012) – at least in terms of jobs and deficits – but also that the main result is an influx of cheap Chinese imports rather than job creation and export industries at home. In 2013, not even Chinese investments continued to rise, even if they are by now by far the world's highest, whereas the number one bright spot was Japan, where renewable investments increased from $9 billion in 2011 to nearly $29 billion in 2013. This is a consequence of the changes brought on by Fukushima. Whether or not the generous FIT introduced in 2011 can however be maintained is an open question. Asano (2012) criticizes it for being both costly and primarily leading to imports from China, and that Japan may end up with the same kind of boom and bust as seen in Europe.

If we break the investments down to wind vs. solar, we see the same trend. Solar investments have increased dramatically. In Germany PV has taken 76 percent of the renewable investments since 2008, and in Japan more than 90 percent. Globally, since 2010, solar PV has attracted more investments than wind power (see Figure 1.9). Still, in 2013, solar PV investments reached their lowest level for three years, primarily because of the European (in particular, the Italian and German) solar boom and bust (PEW, 2014; REN21, 2014). Wind power relies on more mature technologies and has seen less of a drop in costs over the past few years. Thus, it has been less volatile than solar.

That wind is a more robust sector than solar can also be quite clearly seen if we look at the wind turbine and solar PV *industries*. In both industries costs have fallen greatly. Wind turbines prices have fallen by 30–40 percent since 2008, whereas solar PV module prices have dropped by a full 80 percent (before stabilizing and increasing slightly in 2013–14). For wind power, technological progress has been key to explaining the

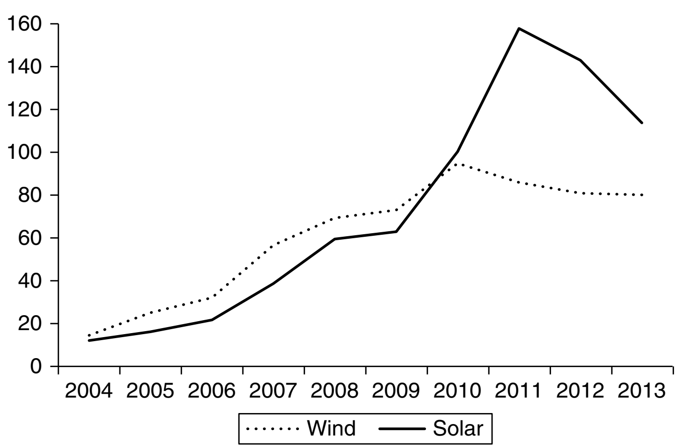

Figure 1.9 Global new investment in wind and solar power, 2004–13 ($ billion)
Source: REN21 (2014).

decrease in costs (although raw material prices are also important). For PV the story is a bit different. Here, essentially PV technologies have become turn-key. The technologies are now fairly commonplace, with energy conversion efficiencies nearing their technological limits. Thus, PV manufacturers are competing on costs rather than on technological sophistication. This may be in the process of changing – REN21 (2014) reports that innovation and product differentiation is again becoming important – but the astonishing cost reductions have come more as a result of oversupply than technological improvements (AWEA, 2014; Caldecott, 2013).

This oversupply stems primarily from China, which very much dominates the global market with a market share of roughly 60 percent. China now also has the largest domestic PV market, but domestic growth is a very recent phenomenon. Until recently, China was a minor player in terms of installations while feeding off generous FITs in other countries, primarily in Europe. Japan used to be the dominant player – it had more than 50 percent of the market share in 2004, and Sharp was the world's largest PV manufacturer – but since 2005, the decline in fortunes has been rapid. China now has 9 of the top 15 PV manufacturers in the world. Market leaders have come and gone. As of 2013, China's Yingli Green Energy and Trina Solar have the largest markets shares (both in crystalline module production and in PV modules). Other big companies include the US First Solar, Canada's Canadian Solar, and Sharp and Kyocera of Japan, but the rest are Chinese. While the rank order of these companies changes around somewhat from year to year, the striking fact is the overwhelming Chinese dominance (*GlobalData*, 2014; REN21, 2013a, 2014).

The Chinese market glut means that Chinese manufacturers are also struggling. But with profit margins all over the world becoming wafer-thin, this favors manufacturers in low-cost countries, such as China, rather than Japan, Europe, or the US. Ernst and Young (2012b) in 2012 predicted that by 2015, 180 solar module companies would go bankrupt (including more than 50 Chinese). A number of once very prominent German firms, such as Solarhybrid, Solon, Solar Milennium, and Q-Cells have already disappeared, whereas Norwegian company REC – a top 15 company as late as 2012 –closed down its Norwegian operations in 2012. The industry has enough capacity for 60GW of installations (China alone at one stage had a capacity equal to almost 200 percent of the world market), but even in the record year of 2013 installations did not go beyond 39GW, with an estimated 45–49GW in 2014, and it is unlikely to go beyond 60GW quite yet (one estimate suggests 56GW for 2015), even when factoring in major growth in China and Japan (*Economist*, 2012a, 2013a, 2013b; *pv magazine*, 2014a; reneweconomy, 2014b; *TU*, 2012b; *SolarServer*, 2015).

Generous FITs in wealthy countries have to a major extent spurred Chinese imports rather than domestic job creation. This is also the reason why solar FITs have been cut in many parts of the world, making the Chinese PV industry far more dependent on having a home market. The bankruptcy of Chinese giant and former market leader Suntech Power shows that even the Chinese are not immune to the glut that they essentially themselves created. Reports speculate that some Chinese manufacturers were losing $1 for every $3 of sales in 2012 (*New York Times*, 2013). China's top-ten PV companies have total debts of $16 billion (REN21, 2014). This can hardly continue. Thus, consolidation needs to happen within China as everywhere else. But this may not come easily, and Suntech itself is proof of that. After its bankruptcy it was immediately bailed out by the local government, which feared for both the social and financial consequences of the company having to close down (see otherwise the China chapter (Chapter 3)). The central government knows that the industry desperately needs to consolidate, but other companies have also been bailed out by local governments. In addition to this, accusations of dumping, against China, from both Europe and the US is creating extra turbulence within the industry.[17]

Consolidation has also been the case in wind turbine manufacturing, but there is already far more concentration in wind turbines than in PV. Whereas in PV the ten largest manufacturers control no more than 40 percent of the market, the ten largest wind turbine manufacturers control more than 70 percent. Another major difference is that in wind, the Chinese, despite having by far the largest home market, and despite accounting for 30 percent of installations worldwide in 2012 and a massive 45 in 2013, are less dominant. Danish frontrunner Vestas has had the largest (although dwindling) market share every year since 1999 (barring 2012). Other major players are Germany's Enercon and Siemens Wind and US' GE Wind. Chinese company Goldwind was second largest in 2013, and other major Chinese manufacturers are Sinovel and Mingyang. However, the Chinese manufacturers rely almost entirely on their home market, and do not export to any great extent, more or less exactly the opposite of the situation in PV.[18]

Developments are rapid. Not long ago 2MW represented the pinnacle of wind power development. As of 2013, the *average* wind turbine size is 1.9MW, whereas the largest commercially available turbines produce

7.6MW. Offshore, 5–8MW turbines are being tested. Onshore, wind-generated power is now often cost-competitive on a per kWh basis with coal- and gas-fired plants, even without subsidies (REN21, 2014).

In the PV sector the main problems have been oversupply and a strong need for consolidation. They are still major problems, but the industry seems to be headed in the right direction. For wind power, the grid net is one of the biggest problems. With the rapid expansion of wind power, evermore countries are having problems feeding ever larger amounts of renewable electricity into the net. Problems range from a lack of infrastructure to delays in grid connections to curtailment of electricity generation. In several countries, the expansion of renewable energy has run ahead of the expansion of the grid system. Thus, lots of primarily wind, but also solar, power has been lost because the grid has not had the capacity to absorb it, and approximate estimates suggest that the European grid infrastructure requires €1 trillion worth of upgrades before 2020, whereas the US infrastructure requires more than $2 trillion by 2035 (*Economist*, 2013e; GWEC, 2014; *Power*, 2014e, 2014f; REN21, 2014).

The holy grail of renewable energy, or at least so it seems, is still grid parity, and so a few words need to be said about this as well. In other words, to what extent is renewable energy actually competitive without subsidies? As always, the answer is complicated and full of contingencies. Grid parity is the point at which an alternative energy source is able to generate electricity for the same levelized cost[19] as the electricity that is available on a utility's transmission and distribution grid. Hence, once grid parity is reached, it should be possible for renewable energy to keep growing even without government support. Grid parity is, however, no neat and easy concept, and implies no fixed value. Instead, electricity rates vary considerably in different locations, and thus grid parity will be more easily achieved in countries with more expensive electricity (the US, for instance, has cheaper electricity than most European countries). There are also differences in how well suited different locations are to wind and solar. Germany – with the world's highest installed PV capacity – receives far less sun than most of the US, and so solar power is less effective in Germany, irrespective of the actual capacity installed, and grid parity will take longer to achieve than, for instance, in California. There is also the difference between retail and wholesale prices. Retail prices (the price paid by consumers) are usually far higher than wholesale prices. This applies in particular to PV, where individual customers are facing retail prices when they decide whether or not to install a solar rooftop panel, whereas for a utility, the wholesale price is what determines whether or not it is profitable to invest (*REA*, 2014; *RenewableEnergyWorld.com*, 2014b).

This means that the answer to whether or not grid parity has been achieved, or when it will be achieved, is: ‘it depends’! Granted, we can be slightly more precise. PV is, for instance, competitive with retail (not wholesale) prices in Germany, Italy, and Spain, as well as in ten US states. Deutsche Bank predicts a second takeoff in solar installations based on their estimate that 19 countries will reach retail grid parity for solar in 2014. In wind power, grid parity was reached in some locations as early as 2010. This, however, varies, as some countries have much longer transmission distances than others, with for instance the US expected to reach grid parity for wind no sooner than 2016. However, the general consensus, irrespective of local conditions, is that grid parity is indeed not extremely far off. There is, however, one or two more problems. If lots of wind (or solar) power is added in areas that are already abundant in wind (or solar) power, days that are calm (or cloudy) will yield major intermittency problems. Thus, unless the transmission net is good enough that power can be easily transmitted from areas with wind (or sun) to areas without, then significant standby capacity is needed as a backup. Thus, for renewable energy to compete, it needs to be both competitive on price *and* able to predictably produce power, all day and all year, irrespective of backup loads from coal, nuclear, or hydro. Thus, even if renewable energy has reached grid parity, intermittency and grid problems may lead to utilities still considering fossil fuels and nuclear as their staple energy. There is an obvious mismatch between the electricity that renewables provide and what the utilities are able to feed into the grid, and this has to be solved for any energy transformation to take place (*Climateprogress*, 2014; *Energías Renovables*, 2012; *pv magazine*, 2014a; *REA*, 2014).

This mismatch, however, also provides a potential source of disruptive change, namely in the growth of what IEA-RETD (2014) calls *prosumers*, that is, energy consumers who produce their own power. PV is the most disruptive of the energy technologies, since it allows consumers to produce their own power. Germany, for instance, has a full 1.4 million PV producers. Thus, where the utilities represent a top-down approach, with large infrastructures, large cross-continental transmission lines, large electricity storage systems, and long planning times, with renewable energy only uneasily included, PV represents a bottom-up, decentralized challenge, where electricity is instead produced locally, by the individual consumer. In countries where retail grid parity has been achieved (as in Germany), it makes good sense for consumers (or prosumers) to produce their own power rather than purchasing it from the utilities, and in doing so driving the growth of a completely different, and rapidly expanding, model of electricity generation (IEA-RETD, 2014; Schleicher-Tappeser, 2012). The IEA-RETD (2014) stresses that we are not yet at a point where a prosumer 'revolution' has occurred, but that prosumers represent the greatest challenge so far for the utility companies that have dominated the electricity markets for the past century, as well as providing major potential for creative destruction in, and a transformation of, the entire utility sector.

The structure of the book

In the following chapters, I will look at the renewable energy policies of six different countries – Japan, China, the US, Germany, Denmark, and Norway. The chapters all include a mixture of comparative and case-study methods. Why these six? These are very different countries. There is obviously a wealth of countries that could have been interesting for the purpose of such a book, and so implicit in every choice of one country, is the omission of another. Yet, in China, Japan, the US, and Germany, we have four of the most powerful and influential economic and industrial powers on the planet, and the policies that they implement will be of huge significance to the rest of the world. Denmark and Norway are two countries that are both too small to serve as movers and shakers of the world economy, yet still highly interesting. Denmark is in many ways the original leader in (modern) wind power and, while its leadership is challenged today by China, the US, and Germany, it very much remains among the leaders. Norway is a completely different story, and in many ways a counterpoint to all the others. With its huge petroleum resources and its hydropower, the Norwegian discourse on energy and renewables has often looked distinctly different from that of other countries. Thus, there is a lot of variation in the policies, the energy structures, the vested interest structures, and even the development level of these countries. This is fertile ground for comparison.

They are all analyzed and compared according to a fairly loose theoretical framework that focuses on the influence of vested interests on energy-political decision-making. Each and every country chapter can be read as complete, stand-alone chapters, independently of the others. However, the vested interest focus provides a unity of perspective. The intention is that while each chapter is a finished whole, they should be structurally so similar that it becomes easy to make comparisons between them. Thus, every chapter starts with an introduction that sketches out the general story, followed by a section on the status and progress of the development of wind and solar power in that country. Then follows a section with a more explicit political economy focus, namely on vested interests and the extent to which renewable energy policy has been constrained by the vested interest structure, before I draw my conclusions in the final section of the chapters. In addition, countries often have country-specific features that do not fit into the overall structure. Thus, several chapters have sections that are specific to that individual country. But, obviously the reason why the chapters are more or less similarly structured is to ease comparison. In other words, the purpose of the book, beyond providing empirical knowledge of the renewable energy policies of six different countries, is to say something more general and systematic about what drives renewable energy policy and the expansion of renewables. Thus, one of the general conclusions springing out of this book is that success within renewables depends crucially on being able to control the influence of its vested interests. That vested interest structures are a major influence in all of these quite different countries goes a long way toward substantiating their importance in the political economy of present-day energy policy, and also substantiating that very often the political constraints against renewable expansion are the ones that need our attention. And that no energy transformation will take place if we lose sight of that.

2
Japan: No Structural Change, Save for a Structural Shock? Vested Interests Pre- and Post-Fukushima

Introduction

Notoriously scarce in domestic energy resources (except for geothermal), but very densely populated and highly industrialized, access to energy has always been a concern for Japan. The oil glut following World War II seemed to have solved the problem. In the words of Jitsuro Terashima (2012), for Japan, 'securing energy supply meant building bigger oil tankers'. The 1973 oil crisis, however, brought energy security back onto the Japanese political agenda. Energy became scarcer, far more expensive, and often arriving from geopolitically sensitive areas.[1]

This caused a serious energy rethink and gave rise to a number of energy policy initiatives and changes. Did it bring Japan to the forefront of renewable energy? This would be a reasonable guess. However, Japanese renewable energy policies have been a mixed bag. There have been major efforts in improving energy efficiency, to the extent that the image of Japan as the most energy efficient country in the world is a well-established one, even if no longer true. The crisis also led to the initiation of major government programs fostering solar power, whereas wind power met with little interest and much resistance.

This chapter explains both the lukewarm overall Japanese effort – only 3 percent of the electricity is produced by renewable energy (11 percent including hydro) – and why solar and wind have been treated so differently (*EIA*, 2014b; *ISEP*, 2014; *METI*, 2014b).[2] As mentioned in the Introduction chapter, we might expect countries with major unsolved energy problems to have ambitious renewable energy policies. However, not only has Japan not performed particularly well in general – the once celebrated efforts in solar petered out in the middle of the previous decade, even if they have been revived after Fukushima – but there also are major differences as to how the state has dealt with solar and wind, differences that can only be understood by looking at the Japanese political economy and to the vested interest energy structure.

Analyzing vested interests is key to understanding Japanese energy policy. They consist of an *iron triangle* encompassing the bureaucracy (in particular the Ministry of Economy, Trade and Industry (METI)), the Liberal Democratic Party (LDP), and business interests. Insiders have been systematically protected, at the expense of outsiders. Politics is opaque, with the government weak and the bureaucracy – in particular METI, the Ministry of Finance (MOF), and the Ministry of Foreign Affairs (MOFA) – exceptionally strong, and with close business ties (e.g. Sakakibara, 2003).

The energy policy-making structure has remained remarkably stable for almost four decades. Granted, there have been political battles, but these have not significantly weakened the vested interest structure, where METI is at the policymaking hub, working closely with, and favoring the interests of, the electric utility companies and the nuclear industry. This structure has kept solar somewhat on the inside, whereas wind power has persistently been on the periphery. Solar needed government support, but it rose within the industrial and institutional framework, drawing on expertise and competencies from already existing Japanese manufacturers, and complemented the structure rather than challenging it. This made it far easier for solar to rise than wind. But requiring even less structural change to the economy has been an approach far more favored by METI, namely energy efficiency. Energy efficiency solutions consist of technological fixes to existing industries and the promotion of high-tech exports. It does not constitute a challenge to any rival interest and is the ultimate vested interest insider approach.

One of the goals of this chapter is to demonstrate the importance of being on the inside rather than the outside of the vested interest structure. However, with the 3–11 (2011) Fukushima disaster, Japan is also quite definitely undergoing its most serious energy rethink since the 1970s. The earthquake and consequent tsunami led to almost the entire Japanese nuclear capacity being shut down, as at one stage or another every plant has been down for either maintenance or safety reasons. While some plants will probably be phased back in, and although the current LDP administration is more favorably predisposed toward nuclear than the previous Democratic Party of Japan (DPJ) administration, Japan still lost nearly 30 percent of its electricity supply overnight.

This obviously has to be replaced. So far, it has been done mainly through a hefty increase in liquid natural gas (LNG) imports, to the extent that Japan for the first time in 30 years now runs periodic trade deficits.

Post-Fukushima Japan does, however, also constitute a window of opportunity for renewable energy, with new legislation and regulations meant to stimulate the implementation, in particular, of solar. In a country that has seen very little structural change to its energy sector, Fukushima constitutes a structural shock to the system. Thus, the very generous FIT that was introduced in 2011 has increased Japanese PV installations from less than 1GW a year before 2011 to 10GW in 2014. Total capacity stands at approximately 25GW, which is bound to keep rapidly increasing, and Japan now has one of the two biggest solar PV markets in the world, on par with China in 2014, but otherwise somewhat behind in terms of sheer numbers. In contrast, wind power has seen no upswing, with installation figures even dropping. In 2013, they were down to only 73MW, a very far cry from the 16GW seen in China that same year. It is likely that the fortunes of wind will pick up (and installations increased slightly in 2014), but it is all within measure. Japan's preference is clearly for PV and the FIT for solar is considerably higher than for wind. Thus, for now, Fukushima has made the difference between solar and wind, which stands at a paltry 2.8GW of total capacity (or just over half the capacity of Denmark), even more glaring. It is still too early to say where Japan is headed. What we can however say, is that Japan is considering its energy future more seriously than it has been for many decades. And while the previous decades have been marked by a near absence of structural change, the structural shock of Fukushima may have just changed that.

Renewables on the inside of the structure: solar power

One of the conclusions of this chapter is that the greater extent to which solar and wind power have had to challenge the existing industrial and institutional structure, the harder it has been to break through. Being positioned differently in the energy vested interest structure is crucial to explaining their different fortunes.

Japan responded to the 1970s oil crises in different ways. The response of the Tanaka administration (1972–74) was to focus on energy efficiency and to massively increase nuclear subsidies. However, a second response was to develop alternative sources of energy. Thus, from 1974 until the early 2000s Japan actively pursued solar power. This was not only about developing alternative sources of energy; it was also an attempt at linking industrial and energy policies. Drawing on traditional Japanese strengths in the manufacturing of high-technology equipment, Japan was hoping for future industrial profits. Thus, within METI in particular, there have always been policy groups supporting solar. And to METI, the success of solar gradually became a matter of prestige, largely synonymous with the success of METI itself.

Solar PV has benefited from government R&D ever since the MITI's 1974 *Sunshine Project*.[3] Perceiving of the country's energy vulnerability, the program was about energy as much as industry, seeking to provide a substantial amount of non-fossil energy by 2000, as well as yielding industrial applications for domestic use and exports (Broadbent, 2002; IEA, 2008; Kimura and Suzuki, 2006). In a shrewd move of bureaucratic politics, MITI realized that the bigger its request for funding, the easier it was to gain publicity and political support, and the more seriously it would be taken (Kimura and Suzuki, 2006). This worked, and from 1974 the Sunshine Project received very substantial funding.

Up until the late 1970s solar thermal had been the mainstay of the program, but MITI was losing faith in this technology. It did, however, want to retain the budget, which, between 1978 and 1981, increased by around 300 percent. Thus, from 1981, funding went primarily to solar panels instead. And so, PV acquired stable and abundant funding from the failure of solar thermal. 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. By 1990, solar power would supply 5 percent of total energy demand, and 7 percent by 1995. The targets were never close to being fulfilled (DeWit and Tani, 2008; Kimura and Suzuki, 2006).

The program convinced the industry that this was a promising emerging market, and so in parallel with the Sunshine Project several companies contributed R&D of their own, even if the government's commitment was probably the main stimulant. It created an assurance that this was a field that would receive persistent funding at a stage where no commercial profits were yet to be had. True, NEC started researching solar power already in the 1950s, and Sharp had since 1963 controlled a minute solar panel market for lighthouses and satellites, but without the Sunshine Project there would have been few incentives to get involved.

In a Schumpeterian industrial twist, the companies that eventually succeeded were not the giants. NEC never joined the program and Hitachi and Toshiba withdrew.[4] In the late 1980s, they did not see market opportunities developing fast enough and felt that solar panels would always remain a niche. Thus, they were leapfrogged by Sharp, Sanyo, and Kyocera, which stayed with the program and went on to become the backbone of the Japanese PV industry. They also organized to form the Japan Photovoltaic Energy Association (JPEA).

This was a period of strong and partially successful lobbying. Partly it was about removing regulatory barriers. For instance, rooftop solar panels used to be classified as 'power generation facilities', requiring an Electrical Chief Engineer for each and every panel installed. Due to institutional inertia, momentum was not created before a series of newspaper articles and TV shows started addressing the regulatory problems. Grid connection was another problem, as Japan's powerful utility companies insisted that solar power was unstable, refusing to allow actors they could not directly control onto the grid. Also, the utility companies were uninterested in contributing to a market 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 if push came to shove, they would be forced to give in (Kimura and Suzuki, 2006). Another breakthrough was the 1995 *Seventy Thousand Roofs* program. It created major industrial growth along with rapidly falling prices, both from technological progress and economies of scale.[5] It was also a major break with past policies, as this essentially constituted a subsidy on installed residential PV systems. The JPEA lobbied heavily for this (Bradford, 2006; Kimura and Suzuki, 2006).

The subsidy expired in 2005, partly because METI had earlier assured the MOF that the subsidy would only run until self-sustained growth was achieved, and partly because of a general swing in favor of market-based policies, initiated by Prime Minister Junichiro Koizumi (2001–06). JPEA lobbying was fruitless. Whether this is proof that there are more powerful bureaucratic actors than METI, or whether individual politicians sometimes make a difference, the end result was the same. In 2005, three of the five biggest solar panel manufacturers were Japanese, and in 2004 the Japanese share of the world market peaked at 50.3 percent (Broadbent, 2002; DeWit and Tani, 2008; IEA, 2008; Kimura and Suzuki, 2006; Roney, 2010). Since then, Japan has lost its number one position. Granted, at the time of its demise, the subsidy had been scaled down to only 3 percent of investment cost, or less than a tenth of what it had been.[6] Thus, in itself the removal of the subsidy may not have been that important. It did, however, send a forceful signal to the market, and in 2005 the number of applicants for PV subsidies slumped by 35 percent, at a time when internationally markets were taking off.[7] As Germany increased its annual installed capacity from 143MW in 2003 to more than 7GW in 2010, installations in Japan fell from a peak of 290MW in 2005 to 210MW in 2007, which was the year that Germany crossed the 1GW a year threshold (see Figure 2.1). Thus, in 2005 Germany surpassed Japan in terms of total capacity (since then China has done the same). Sharp was the PV market leader between 1963 and 2008, but since then quickly descended down the ranks, and Japan today controls only 6 percent of the global PV module and 8 percent of the PV cell market (which is, however, a clear improvement on 2012, see Figure 3.1), with China being supremely dominant. As prices for PV modules have fallen dramatically, profit margins have dropped, making it far harder for a high-cost country such as Japan to compete. Sharp and Kyocera are still in the top ten in terms of market share, but for the foreseeable future, China looks to increasing its advantage rather than surrendering it (Asano, 2012; *EPI*, 2013; *Greentechmedia*, 2014a; *GTM Research*, 2014; Huenteler et al., 2012; REN21, 2012, 2014; Roney, 2010).

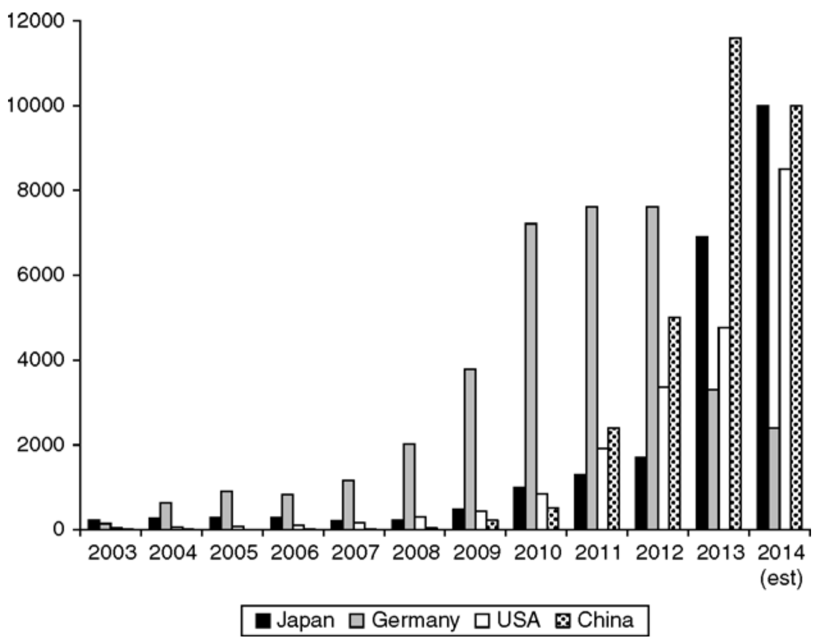

Figure 2.1 Annual PV installations, Japan, Germany, the US, and China, 2003–14 (MW)

Sources: Burger (2015); EPIA (2014b); PEW (2014); *pv magazine* (2014b); REN21 (2014); *SEIA* (2015).

It is, however, by no means all doom and gloom for Japanese PV, the politics of which I will return to in the post-Fukushima section of this chapter. It may not be realistic for Japan to regain its number one spot, but even prior to Fukushima, policy had taken a turn for the better. A subsidy was re-introduced in January 2009, and following the election victory of the DPJ, a FIT was introduced. This immediately doubled annual installations, which doubled again in 2010. And developments have accelerated further since the Fukushima disaster. First, the nuclear gap, resulting from 30 percent of electricity production disappearing overnight, has led to a major increase in demand for renewable energy. Second, in August 2011 a very generous FIT was introduced. The effect has been immediate. Installation figures shot up to almost 2GW in 2012, nearly 7GW in 2013 and approximately 10GW in 2014, converting Japan overnight into the world's second largest PV market, and in 2014 maybe even marginally bigger than the Chinese (installations will probably however drop somewhat in 2015). Whereas Japanese PV used to be primarily about rooftop installations on residential homes, for the first time it is now the non-residential sector that drives developments. This is likely to continue, as is the rise of the domestic market, even if the FIT has since been reduced somewhat. NEDO has upgraded its 2020 PV capacity target from 14GW to 28GW. The 14GW target was nearly achieved already in 2013 and by the end of 2014 Japan was at 25GW, thus the 28GW target is realistically going to be reached as early as 2015. This will probably not regain Japan its first place in terms of market shares. Since the introduction of the FIT, the share of imports has increased from 15 percent in 2010 to 56 percent in 2013, the great majority of which from China and Taiwan. In other words, the Japanese solar boom to a major extent benefits foreign manufacturers rather than domestic ones. Also, the argument has been made that the reason for Japan's PV failures since 2005 is not about the phase-out of subsidies, but about problems in the Japanese PV industry (Asano, 2014). At the time, crystalline silicon manufacturing technologies were being standardized, spreading to China and Taiwan, which quickly expanded their production volumes. But Japanese firms failed to secure ample supplies of silicon, and this delayed them in scaling up production. The fear that silicon would be hard to procure led Japanese firms to go for thin-film instead of crystalline silicon. And the thin-film market has not lived up to expectations. In 2012, crystalline silicon modules accounted for 89 percent of the global module market. Thus, if subsidies were not the reason for the fall of Japanese PV, but instead industrial problems and miscalculations, then it probably takes more than a FIT to resurrect the

Japanese industry. Still, the FIT ought to provide ample growth opportunities for Japanese PV manufacturers, and the short-run consequence has been upswings for Sharp and Kyocera. Indeed, during the first quarter of 2014, and for the first time since 2008, Sharp again led the world in PV sales, and from 2012 to 2013 Japanese PV cell production increased by 40 percent and PV module production by 23 percent (EPIA, 2014a; Ernst and Young, 2014a; *GlobalData*, 2014; *Greentechmedia*, 2014a; *GTM Research*, 2014; *METI*, 2014a; REN21, 2014; *Solarbuzz*, 2014; Vosse, 2014a).[8]

Renewables on the outside of the structure: wind power

Most countries have pursued wind power to a far greater extent than solar. Japan has, however, largely neglected wind, to the extent that wind power comes forth as the ultimate outsider. Wind power accounts for 0.5 percent of electricity supply, as compared to 39 percent in Denmark (GWEC, 2015; REN21, 2014).[9] For solar, Japan invented an incentive structure to be emulated. But its wind power industry has suffered from exactly the same vested interest structure that solar has benefited from. There are no major interests speaking on behalf of wind, and while wind turbines ought to be a promising area of industrial success, few domestic industries have seen it as a natural extension of their existing activities.

There have been attempts at supporting wind. A subsidy system was enacted in 1997. While hardly comparable to the leaders, wind power capacity increased at roughly the same pace as for PV, from 136MW in 2000 to 2.5GW in 2011 (see Figure 1.5). Regulatory change in 2007 set most companies back a year, and 2008 saw the financial crisis. Hence, the 2010 target of 3GW was long unreachable. In 2010, Japan installed only 197MW of capacity, and instead of increasing, following Fukushima, this has kept dropping, to only 73MW in 2013, compared to 3GW in Germany and 16GW in China. Thus, whereas the new FIT (at ¥22/kWh the FIT for wind is significantly lower than for PV (¥27/kWh)) has had dramatic effects on PV installations, wind is flat: In 2008, Japan installed more wind power than solar power; in 2013, it installed nearly 100 times more PV than wind (see Figure 2.2)! There is more wind power in the pipeline, and part of the blame for the current standstill must be taken by the Environmental Impact Assessment law that was introduced in 2012, which has seriously delayed installations. Interest has increased following Fukushima, suggesting that installations will eventually pick up. But for much of the recent past, the Japanese market

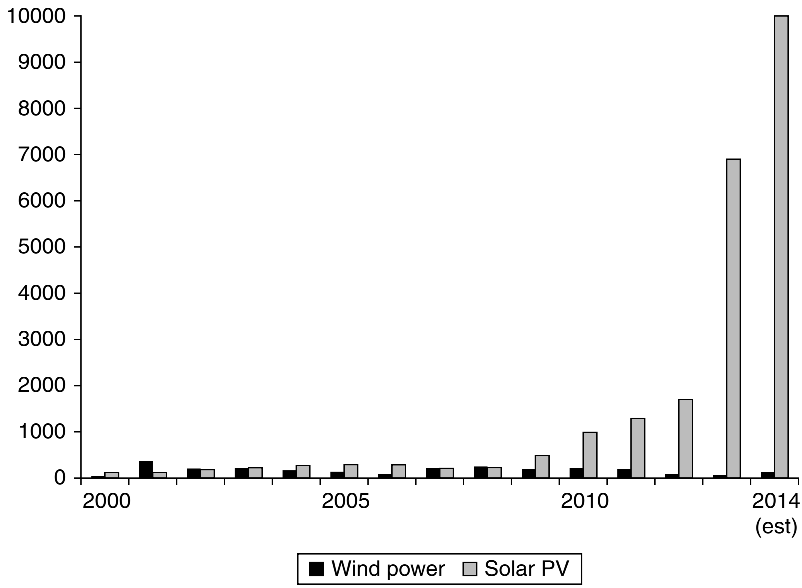

Figure 2.2 Annual installations of wind power and solar PV in Japan, 2000–14 (MW)

Sources: GWEC (2014, 2015); PEW (2014); *pv magazine* (2014b); REN21 (2014).

just has not been particularly interesting. In Japan, annual installations of on average around 200MW have typically been divided between 10 and 20 customers. In comparison, Mitsubishi Heavy Industries, in 2007, landed a single US order for a total capacity of almost 1.4GW. It has made more sense for Japanese manufacturers to look abroad (Ernst and Young, 2014a; Iida, 2010; Inoue and Miyazaki, 2008; *JCN Network*, 2007; *METI*, 2015; REN21, 2014; WWEA, 2012, 2013).

In addition, where there is an official 28GW target for PV, the wind power target is a far less impressive 5GW. To this can be added an offshore wind target of 1GW by 2020, 8GW by 2030, and 37GW by 2050. Thus, in the long run, offshore wind may hold more promise than land-based wind. TEPCO (Tokyo Electric Power Company) early on got involved with the University of Tokyo to develop a floating wind-farm. Mitsubishi has recently announced a joint venture with Vestas, and in 2013 two offshore 2MW deep-water turbines were floated, due to be replaced by 7MW turbines in Phase II of the venture. In 2013, the Industrial Competitiveness Council declared that by 2018 Japan should be the first country to commercialize floating wind turbines, and in 2014 the FIT for offshore wind was increased (until then it was the same as for onshore wind). Thus, there may be less political hurdles standing in the way of offshore than land-based wind. However, the technologies are still immature, and there is much uncertainty as to when offshore will constitute a realistic alternative. The Japan Wind Power Association (JWPA), for instance, claims that the FIT needs to be raised further – from the current ¥36/kWh to approximately ¥50 – for offshore projects to be profitable. This is, however, an area where Japan is becoming rapidly more active (Engler, 2008; Ernst and Young, 2014a; Hill, 2008; *Japan Times*, 2013; *New York Times*, 2008; *offshoreWIND.biz*, 2014; REN21, 2014).

Vested interests

After World War II, Japan was set up with a weak executive, to prevent a return to authoritarianism and nationalism, but with a strong bureaucracy to run the state. This was where continuity and expertise resided, with politicians often inexperienced and understaffed. Links between the bureaucracy and business were strong, but they became pathological from the mid-1970s. As the LDP reigned unchallenged, election results had little impact on policy. What mattered was which LDP faction held power. Kakuei Tanaka, prime minister between 1972 and 1974, above all symbolized the transition to a state where economic success depended on massive side-payments, where all important decisions took place behind the scenes and where weak domestic sectors received persistent sheltering. This was the start of endemic vested interest problems (Emmott, 2009; Katz, 2003; Schlesinger, 1999). While the brazen corruption of the Tanaka era is gone (it is now at least less blatant), what persists is a system where the government is weak, the bureaucracy exceptionally strong, politicized, and where business ties are close. This is an environment that is still very conducive to vested interest abuse.

The close business ties means that the bureaucracy often has strong preferences and major policy influence, and that it often treats the main industrial interests sorting under it as its 'clients'. METI (including NEDO) is the main bureaucratic actor, and the electrical utility companies among its biggest clients and the main industrial energy actors. Thus, there has been a strong convergence of interest between the two and METI has often furthered the interests of the utilities. This has given the utilities major power, and with the bureaucracy they constitute an obvious part of the Japanese energy vested interest structure, even if when push comes to shove, METI calls the shots, not the utilities. The low civil service retirement age (55 years) results in prominent civil servants 'retiring' to top-jobs in exactly those companies that they were dealing with as civil servants.[10] This preserves a 'harmony of interest'. It is in the bureaucrats' personal interest to foster a good relationship with the client. This has led to METI, specifically its Agency for Natural Resources and Energy, giving strong preference to the utilities in matters of energy policy, almost entrenching utility interest within the bureaucracy. Their interest organizations – primarily the Denjiren (the Federation of Electric Power Companies of Japan) – have been adamantly opposed to any rival power-generating actors, and they own both nuclear and thermal facilities. The utilities have traditionally also had a very close relationship with the party apparatus of the LDP, and the LDP has had a very strong relationship with the bureaucracy. The LDP has traditionally consisted of multiple rival factions. It has been described as exchanging 'votes for money, money for favors, favors for positions, positions for patronage, then patronage for votes, and so on' (Castells, 2000, p.232). 'Almost every interest-group imaginable is represented within its ranks, and it takes care to look after them' (Grimond, 2002). This is a political party with a long history of pork-barreling (DeWit and Tani, 2008; Emmott, 2009; Engler, 2008; Grimond, 2002; Katz, 2003; Luta, 2010).

With industrial and economic growth a main METI concern, energy policy has been framed primarily in terms of satisfying a growing energy demand without impeding economic development. Energy policy goals have been set in cooperation with the industry, resulting in lenient targets and voluntary emissions reductions schemes (Luta, 2010). Developments seen in countries such as Denmark, where renewables have been supported so as to fulfill Kyoto commitments, have been absent.

METI consists of different policy groups, and so while the relationship with the utilities has been tight, policy is not predetermined. In the late 1990s, market fundamentalists inside METI (typically from Tokyo University Law School) held the upper hand, promoting market liberalization and deregulation, among other things of the utilities. However, international developments (such as the collapse of Enron in the US) paved the way for more conservative policies and for a policy group consisting of engineers and technology-oriented people (typically from Tokyo University Engineering School). The result was an end to deregulation efforts, only *semi*-deregulated utilities, and no unbundling of electricity generation and transmission – unfortunately for wind power. The utilities also regained their influence with METI, making for a more conservative METI with less-ambitious renewables policies.[11] While METI is no neutral actor, it is also not a monolithic one. Thus there are groups within METI representing the solar industry, going back to the energy security initiatives of the 1970s. There is, however, no METI group speaking out for wind and little cooperation between solar and wind. Both naturally lobby for favorable arrangements for their respective industries, but only solar has been able to influence policymaking to any great effect. Other bureaucratic actors with some influence on energy policy are the Ministry of Finance, the Ministry of Foreign Affairs, and the Ministry of the Environment (MOE). MOE is the one with the stronger viewpoints, but has little influence except for during special windows of opportunity.

Between 2003 and Fukushima, the main Japanese policy instrument for phasing-in renewable energy was the Renewable Portfolio Standard (RPS), obligating the utility companies to supply a certain share of their electricity from renewables. However, at a very low 1.35 percent of electricity output by 2010, this provided no stimulus for renewables (IEA, 2008). Thus, the main government policy instrument put no pressure or provided any incentive for the utilities. The low RPS target is widely blamed on the influence of the utilities on METI. Unlike in Europe, a FIT was never on METI's agenda. The utilities strongly opposed it, and no major METI groups were in favor. Even the RPS was probably only introduced to pre-empt *outside* efforts at introducing a FIT. In 1999, a collaborative effort between Diet members[12] and an environmental NGO led to an unsuccessful Diet initiative to introduce a FIT. The law was fought by METI and the utilities and was never passed. To counter, METI proposed the RPS. The 2001–02 political fight over the RPS was protracted and politicized, but ended with the utilities and the METI mainstream winning out (DeWit and Tani, 2008; Maruyama et al., 2007). However, the tug-of-war caused profound consternation within METI as the perception was that an outside rival for power (the parliament) had sought to wrest energy policymaking away from it. Thus, after the passing of the RPS it became politically hard to put renewables back on the agenda (Iida, 2010; Maruyama et al., 2007).

With the LDP, METI usually got its way, largely because of its connections inside the party.[13] But by 2008–09, four decades of near uninterrupted LDP rule was coming to an end. The DPJ came to power in September 2009, explicitly vowing to combat the iron triangle. This caused great concern within METI, and attempts were made to pre-empt the DPJ. One DPJ election promise was a general FIT for all renewables, duly introduced in November 2009. However, there is a twist. In 2008, an

LDP climate change policy group recommended a FIT. The idea received the backing of MOE as well as the other political parties. This took METI by surprise, and with extreme haste it launched its own FIT proposal, not wanting to lose control over the process. 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 who were strongly against any FIT. Only a month after the election, the Denjiren stated that it would do anything to restrict the FIT, meaning no smart grids and keeping renewables beyond solar out (DeWit, 2009). METI's FIT was the FIT that was implemented, giving almost exclusive preference to solar, and applied to surplus power only (so, only to the electricity produced in excess of the owner's own consumption of power), not gross power. While now defunct, there is little doubt that the METI FIT was meant to pre-empt a more comprehensive scheme.

Recognizing this tug-of-war between government and bureaucracy is key to understanding Japanese policymaking. At the start of its reign, the DPJ sought to bypass the bureaucracy by creating inter-ministerial taskforces. This collapsed, bringing energy policy back in the fold, where advisory councils within each ministry produce separate roadmaps. The councils (shingikai) balance the interests of unions, energy suppliers, industry, consumer groups, and so on. The DPJ lost the tug-of-war battle by battle, with METI solidly at the policymaking hub. Personnel, institutions, and routines remained unchanged. This went so far that prior to Fukushima the *new green growth* policy almost completely bypassed renewables, instead combining two favorite METI obsessions, exports and nuclear power. Nuclear was redefined as green power, and thus nuclear exports became green growth, without any sacrifices having to be made in terms of domestic structural change. Former Prime Minister Yushihiko Noda confirmed that the export policy stood firm even post-Fukushima, and with the present LDP administration of Shinzo Abe, this is unlikely to change. Mitsubishi, in cooperation with French partner Areva, will, for instance, build four nuclear reactors in Turkey, starting in 2017 (*asahi.com*, 2011b; DeWit and Iida, 2011; Iida, 2010; Scalise, 2010; Umbach, 2014).[14]

Hence, the bureaucracy (and every LDP administration) always preferred nuclear. In METI's 2006 'New National Energy Strategy' the focal points were energy efficiency and nuclear (Luta, 2010). However, Japan is one of the world's most earthquake-prone countries, with accidents, scandals, and lucky escapes.[15] This has led to rampant NIMBYism, with huge compensation costs to various actors before nuclear could be installed in anyone's neighborhood.[16] Hence, electricity remains expensive, but as compensation costs were not part of official estimates the official cost of nuclear electricity remained artificially low, enabling METI and the utilities to consistently produce figures showing how nuclear was cheapest. Most likely, wind would be competitive if compensation costs were included (Iida in *Japan Times*, 2007). DeWit and Kaneko (2011) suggest that even solar might sometimes be on par with nuclear.[17]

In 2005, Japanese nuclear R&D amounted to twice that of the other 25 IEA countries combined and more than 60 percent of total Japanese energy R&D. Even after Fukushima, this figure remains above 50 percent.[18] Of total Japanese energy subsidies (1970–2007) nuclear received ¥9.7 trillion ($120 billion) against ¥1.7 trillion ($20 billion) for renewables (DeWit and Iida, 2011; Iida and DeWit, 2009; Oshima, 2010; Pickett, 2002; Schilling and Esmundo, 2009; Umbach, 2014). In METI's 2010 revised Basic Energy Plan (*AEEC*, 2010), future energy needs were to be met primarily through the construction of 14 new nuclear plants (12 by 2020), which by 2030 would increase the nuclear share of electricity supply from almost 30 percent to 50 percent (in all fairness the plan also included a goal of 20 percent electricity by renewables (including hydro) by 2030). Even NEDO saw nuclear as the only realistic way to boost energy supply and reduce GHG emissions.[19] However, in terms of reducing GHGs, opinion polls have shown that the public in general has been in favor of renewables.[20] METI, the utilities, and the 'nuclear village' have, however, responded by ridiculing renewables as 'insignificant boutique power sources' (Midford, 2014, p.79).

Business associations such as the Denjiren also pushed for the continuation of energy policies based on nuclear. The nuclear skepticism of the DPJ administration was met by the Denjiren stating that nuclear is key to Japan's energy future and that the DPJ must respect the continuity of important national policies. The Denjiren also explicitly attacked DPJ's goal of reducing GHGs by 25 percent (1990–2020), rejecting policies employing renewables to meet future climate commitments (*FEPC*, 2009).

Fukushima notwithstanding, the enormous amounts of money that Japan has invested in nuclear, not just in actual nuclear plants, but in research, personnel, and expertise, makes it very hard to foresee a future where Japan decides to let all of its nuclear capital go to waste.

Energy efficiency does not challenge vested interests

Beyond nuclear, the second preference of the Japanese vested interest structure is energy efficiency. Since the 1970s oil crises, few countries have lauded energy efficiency as more of a major strategy. For a country devoid of natural resources, this is an intuitive strategy. However, energy efficiency now seems as much rhetoric as anything else.

Still, the accepted wisdom for long was that Japan responded to the oil crises by becoming the most energy efficient country in the world (IEA, 2008; Smil, 2008). This is also the official story. The Japan Research Institute (Nihon Sōken) emphasizes Japan's commanding lead (DeWit and Tani, 2008), and Akihiro Sawa (2009, p.4) of the Nippon Keidanren 21st Century Public Policy Institute adds: 'All countries in the world know very well that Japan tops the world in energy efficiency.' And impressively enough, between 1977 and 1987, GDP increased by 42 percent whereas energy demand increased by only 14 percent and energy intensity decreased by 21 percent (Luta, 2010).

Yet, DeWit (2009), DeWit and Tani (2008), and Iida and DeWit (2009) have resoundingly punctured the myth that Japan is miles ahead. Since the latter half of the 1980s, Japanese energy efficiency has been at a virtual standstill. The basis for asserting a Japanese lead rests on using market exchange rates to compare efficiencies rather than purchasing power parities (PPP), and on lumping every EU-country together, when there are quite major differences between them. While Japan is no slouch, several countries have caught up with it and in some respects forged ahead. On CO_2 emissions per unit of GDP and tons of CO_2 per capita and per total primary energy supply (TPES), Japan lags all the European countries in this book, in addition to several other EU countries, and a comparison between Germany and Japan reveals that since 1990 German GDP has increased by 35 percent and GHG emissions dropped by more than 20 percent, whereas Japanese GDP has risen by only 20 percent, with GHGs remaining constant (DeWit and Tani, 2008; IEA, 2014c; Iida, 2014; Iida and DeWit, 2009). The main difference is between Japan and Western Europe on the one hand and the US, which emits far more than the others in per capita terms, on the other. China, as the developing country that it is, unsurprisingly does badly both on CO_2 emissions per unit of GDP and TPES per unit of GDP (see Table 2.1).

What was it about the Japanese political economy that made it opt for energy efficiency? It could be argued that strong vested energy interests make energy saving a puzzling strategy. After all, when electricity consumption falls, the utilities lose profits. However, the 1970s oil crises forced Japan to reappraise its national interest in terms of energy security. Energy efficiency was an energy *security* strategy, initiated by MITI, and thus a strategy of *national* interest, not business interest. Thus, in

Table 2.1 Different emissions indicators for select countries, 2012

	Japan	China	USA	Norway	Denmark	Germany	France	Britain	Sweden
TPES/GDP (PPP)	0.11	0.22	0.15	0.12	0.10	0.11	0.13	0.09	0.15
Tons CO_2/TPES	2.70	2.84	2.37	1.24	2.14	2.42	1.32	1.81	0.81
Tons CO_2/Capita	9.59	6.08	16.15	7.21	6.64	9.22	5.10	7.18	4.25
CO_2/GDP (PPP)	0.31	0.63	0.36	0.15	0.21	0.26	0.17	0.22	0.12

Notes: TPES = total primary energy supply; PPP = purchasing power parity.

Source: IEA (2014c).

the 1970s and 1980s, energy security was not subject to strong vested interest pressure. Also, the rapid expansion of nuclear power was a vital part of the energy security strategy, which very much played into the hands of the utilities.

Also, this was a strategy of technological fixes, not structural change. Japan has for long been known for its dual economy, held together by the iron triangle, where super-efficient, high-tech export industries live side-by-side with stunningly *in*efficient services (Grimond, 2002; Katz, 2003; Sakakibara, 2003). The energy efficiency strategy does not challenge this. Rather, it encourages new technological solutions to existing problems, playing into the hands of the high-tech industries and opening up new export opportunities. These are concerns that have always been central to, and received, strong backing within MITI/METI.

In general, the strategies propagated by bureaucrats and politicians have been a blend of technological fixes, nuclear expansion, not rocking the boat, boosting exports, and thus aiding economic, energy, and climate policy all at once: The 2008 Fukuda Plan set a goal of reducing emissions by 60–80 percent by 2050, creating a low-carbon society through new, innovative technologies. Bureaucrats and politicians alike take pride in marketing Japan as a high-tech, low-carbon society. Thus, energy consumption should be reduced through energy efficiency measures and by exporting emissions-reducing technologies to developing countries (*MOFA*, 2008).[21] It shifts the focus away from domestic problems and emissions, preaching METI's ubiquitous solution to all of Japan's problems, namely increasing high-tech exports. It leaves every conceivable vested interest happy as it makes no demands for structural change. Politically it is the path of least resistance.

However, even the energy efficiency strategy has been hollowed out by vested interests. Pre-Fukushima Japan seemed ever happier to guzzle up petroleum at world market prices, and beyond that relying on nuclear. Most of Japan's energy efficiency improvements happened before 1990. Since then, energy efficiency improvements have slowed to a crawl, as the economy ground into depression and cutbacks were made to clean energy investments. The iron triangle of LDP, METI, and the business associations (primarily Keidanren (the Japan Business Federation)) has allowed for very lax emissions regulations, letting the major industries write their own voluntary emissions targets and allowing them to regulate themselves. Pre-Fukushima energy plans were lenient on industry, opaque, and hard to evaluate. In an economy that experiences zero growth, and where the main priority is on preserving jobs and competitiveness, giving in to vested interests makes good political sense, even if from an energy efficiency perspective it does not.

Most of the opposition to energy efficiency initiatives came from Keidanren. Granted, between 1990 and 2007 industrial GHG emissions decreased by 4 percent, but this was mainly because the energy conversion industries were exempt. Accounting for 40 percent of national emissions, these increased their emissions by 24 percent between 1990 and 2006. All the blame should, however, not fall on the industry. Between 1990 and 2006 residential and commercial emissions rose by 30–40 percent and overall electricity demand also kept increasing, with little effort spent at increasing consumer energy awareness (Iida and DeWit, 2009; Kondo, 2009; Luta, 2010; Yamaji, 2012). While it is hardly surprising that economic crisis leads to cries for regulatory leniency, it also makes the vested interest explanation for the energy efficiency slowdown very obvious. Energy efficiency has remained the energy mainstay of Japanese administrations and the METI for four decades. However, the evident hollowing out of this strategy can make one wonder if energy efficiency is now primarily a device of political rhetoric.

Why solar over wind?

What explains the Japanese preference for solar? Cost effectiveness was certainly not the reason. METI (2010), in 2010, estimated the cost of wind power at ¥9–14/kWh, compared to ¥49/kWh for solar PV. Since then, PV prices have dropped by 80 percent worldwide, making the difference far smaller (wind power has also become 30–40 percent cheaper), but for as long as solar has been favored by the Japanese state, it was considerably more expensive than wind.

Thus, the main reasons why Japan opted for the most expensive renewable energy are political. They also stem from path-dependencies. Drawing on a long tradition of solar power for water heaters, it could be argued that in 1974 solar was the natural choice. And attitudes toward wind power have at times been distinctly unfavorable. As late as 1990, NEDO declared large-scale wind power unfeasible. Thus, as solar received its first major subsidies, wind was not on the agenda, partly because the weather was thought of as too rough (choppy winds and regular typhoons), and because of a lack of available land beyond the rural areas.

But solar PV was also intended as a commercial strategy, creating new exports, whereas wind was always about power supply only. Within solar, Japan could rely on a host of already industrially healthy companies. Thus, in addition to energy security, for MITI, this was always a strategy that harbored long-term export potential. The promotion of new exports is at the core of MITI/METI activities, and this made it much harder for vested interests to work against solar. The argument should not be overplayed. It took 20 years for commercialization to occur, and it might not have happened at all. By 1993, cumulative government investments had reached ¥600 billion ($7.5 billion), with practically nothing to show for in terms of commercialized technologies. In most countries this would have prompted a shut-down. MITI made the opposite argument, namely that to prevent the failure of a program that had already been heavily funded, funding should instead be scaled up. As NEDO and MITI were under strong political pressure for the program to be commercially successful, a full solar subsidy and deployment program was seen as the only solution (Bradford, 2006; Kimura and Suzuki, 2006). 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 to ensure favorable terms for PV, both as export industry and power supplier. To METI, solar is a success story, and NEDO's pride in Japan as the world's number one in solar panels was palpable (e.g. NEDOBOOKS, 2007). Pride and prestige, as well as Japan hosting the 2008 G8 summit and feeling pressured to come up with some kind of policy achievement, may easily have been the most important reasons why Japan, in 2009, re-introduced the subsidy (Iida, 2010). Path-dependencies have been reinforced by the vested interest structure. From a cost-effectiveness angle, this may not have been sound business, but from a political point of view it makes more sense. And as the solar programs and subsidies have been allowed to live on, they have become ever more entrenched within the government apparatus, hinting at a growing institutional bias in favor of solar.

Solar has enjoyed considerable support, and there is no doubt that this was crucial to its rise. But when comparing solar to wind, what has also been evidently clear is how much easier it is for an industry to succeed if it is able to work within existing industrial and institutional structures; that is, if it has the vested interest structure actually working *for* it. The success of PV was relatively frictionless – accomplished without changing any major institutional, industrial, or organizational structures (with some exceptions such as the NEDO demonstration project and the 1980s regulatory changes). They were the same politicians, bureaucrats, and business elites finding ways to pursue new industries within the bounds of the system.

Having been supported by parts of the bureaucratic apparatus, solar was always on the inside. Building a solar industry without MITI/METI would have been tricky. At several critical junctures the nascent industry could have fallen by the wayside. First, MITI asked for a big budget, assuming that a big project would be taken more seriously and more easily become a permanent budget feature. At the next big juncture – the lack of progress in solar thermal – MITI shielded the budget and even received a huge increase because of the 1979 oil shock, then funneled it into PV. As the utilities were reluctant to let solar onto the grid, NEDO's four-year pilot to demonstrate the system's suitability forced the utilities to give in. As there had been no unbundling of transmission and generation, the utility companies could physically have shut solar out. But the JPEA cooperating with sections of NEDO and MITI, and boosted by public pressure, successfully pushed for regulatory change. When focus was cast on the lack of technologies that were brought to the market, MITI used the amount of money already spent to argue that Japan should fund deployment as well. Thus, solar at important junctures had major players fighting for it and committing to it, at the expense of existing actors in the Japanese energy-industrial complex.

Wind did not have such support. But wind also challenges the existing industrial and institutional structures far more severely. In terms of industrial policy, solar was a more obvious fit. The potential customers of PV were individual households (and businesses), and it is easier to create discreet products sold to individual customers. From the inception of the Sunshine Project, MITI always saw greater potential for commercialization of solar, and so solar fit into MITI's preference for high-tech exports. If we were to make a distinction between energy policy and industrial policy, wind power in Japan has been almost exclusively energy policy. It is about increasing energy supply. Solar policy was, however, always energy *and* industrial policy.

Another way in which wind far more seriously challenges the vested interest structure is in how the power is supplied. PV is typically installed on rooftops on individual buildings. Since most houses need electricity, they are already grid-connected, and so the solar panel is automatically connected.[22] A wind turbine is, however, typically set up away from the grid. This leaves the question of who should pay for the cost of connecting it. Until very recently, unbundling of electricity into transmission and generation never occurred. Thus, the utility companies had the opportunity to essentially shut wind power out from 'their grid'. This they could never do with rooftop solar.

One wind power unit (a wind turbine) also provides far more energy to the grid than one rooftop solar panel. As it provides more power per unit, it requires a bigger investment in terms of grid lines. But typically, the grid is weaker in the countryside where most wind turbines are located. With solar, each power generator is too small to heavily affect the grid. And they are located in populated areas, where the grid is already strong. Instead, for wind the most important issue is priority access to the grid. Without this, wind power cannot grow, almost regardless of other regulatory changes. For short, the degree of structural change required is far greater than for solar.

The main problem is that Japan is divided into ten electric utilities – each with a regional monopoly – and they have all strongly opposed unbundling. Quite likely, one of the beneficial consequences of Fukushima will be the eventual unbundling of generation and transmission, but up until the tsunami struck, the utilities always had enough influence in METI to get their way. For them, letting wind power onto the grid was to some extent like acquiescing to a process of liberalizing the entire electricity sector. This they fought tooth and nail for 15 years, as they have had no interest in letting rival power producers into the market. Since wind power is produced by independent power generators, for the utilities they essentially represent a competitor. And so, for them, buying electricity from wind power generators is like making a contribution to the enemy. Also, the belief that over time energy consumption will drop (seeing as Japan experiences negative demographic growth and is likely to improve in terms of energy efficiency) makes inviting in rival power producers seem like very bad business. Consequently, the opposition against wind has been far stronger than against solar. Solar goes straight to the individual house, and this house will already be a customer of the utility. And the utilities are very reluctant about refusing their customers (e.g. Iida, 2009; Mortensen, 2009).

Therefore, the problem runs deeper than merely having no major interests speaking for it. METI consists of a number of policy groups. The image of Japan Inc, immortalized by Chalmers Johnson's (1982) *MITI and the Japanese Miracle*, is one that we have abandoned. Yet, none of the major groups speaks for wind power, unlike what is the case for solar. Even NEDO concluded that large-scale wind power was unfeasible. Moreover, powerful interests have been blocking wind, most prominently the utilities and the nuclear lobby. 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', limiting wind energy to 2–3 percent of the electricity flowing on the grid.

Whether genuine or merely excuses, wind power has met with a number of objections. One is that Japanese weather conditions are particularly difficult, with choppy winds and seasonal typhoons. Between 2004 and 2007 several turbines were severely damaged, leading to new safety standards: the J-class windmill, and a new building code classifying wind turbines taller than 60 meters as buildings. This made the application procedure complicated, expensive, and lengthy. While the construction law itself was probably not a bad thing,[23] bureaucracy increased. A Japanese wind power application takes several years before a wind turbine is installed, somewhat akin to the situation in Norway (see Chapter 7). Similar processes in other countries are far shorter. Regulatory changes are also at least partly to blame for the most recent no-growth in installations. The wind industry, however, strongly feels that using wind conditions as an argument is primarily an excuse. Wind conditions do not present insurmountable technical obstacles.

The primary objection of the utilities has, however, always been the variability of the power source. If unstable and unreliable, the utilities cannot afford to admit it into the grid. The intermittency argument is, however, not lobbied also against solar. With the 1986–90 NEDO demonstration project, the bureaucracy strongly committed to solar and essentially left the utilities no choice but to accept the usability of solar (whether fictional or real). While intermittency arguments are less critical in areas where the grid is already strong and where singular solar panels only has incremental influence, this was a commitment that no group within METI would ever make on behalf of wind. What it clearly demonstrates is the importance of being on the inside of the vested interest structure rather than on the outside.

The intermittency argument is backed up by a reference to the peculiarities of the Japanese grid. In a large, integrated grid, such as in the EU, fluctuations in the power supply of wind even themselves out. But Japan's population is only a fourth of the EU's, and Japan is not connected to any foreign grid from which it may draw in case of crisis. Further, the grid is not very integrated. Inter-grid connections between the ten regional monopolies are weak, and Japan does not even run its grid on the same nationwide frequency – south-western Japan running on 60Hz and the north-east on 50Hz. There are examples of this affecting solar too, especially since its rapid expansion after Fukushima. The Hokkaido utility company HEPCO in 2013, for instance, decided to limit solar capacity connections to 400MW, with the result that more than 1GW of PV applications will be refused. Thus, the vulnerability and reliability argument is more credible than in most countries. It also means that major wind power expansion requires greater infrastructural investments than would solar (*Alternative Energy*, 2006; Ernst and Young, 2013c).

Still, there is a strong feeling (e.g. Iida, 2009; Lund, 2009; Mortensen, 2009; Okumura, 2009; Yarime, 2009) that the utilities are overplaying this argument. Power was, for instance, quite easily transferred between different power regions and companies after the 2007 Niigata earthquake. Also, typical claims about the reserve capacity of the utilities being significantly lower than in Europe rests on accounting techniques whereby capacity under maintenance and potential capacity imported from other regions are excluded. Thus, genuine reserve capacity is less critical than the utilities profess. It has also been argued that the grids are in fact far better connected than the utilities claim, and that regulating the grid so that renewables is given priority access, but subject to temporary removal in case of crisis, would be a fairly seamless way of improving the conditions of wind power. A conversation between LDP Diet member Taro Kono and US officials in 2008, documented by Wikileaks (2008), revealed a strong suspicion from the MP that in Hokkaido, the utilities were simply refusing to utilize unused power lines between Hokkaido and Honshu for transporting wind power, deliberately preventing the development of renewable energy, the main reason for which would be concerns that wind would compete with nuclear (Midford, 2014). Offshore wind may be a way around some of the vested interest problems. Yet, problems apply here too. Iida (in Engler, 2008), for instance, warns that offshore windmills may face vested interest problems, not from the utilities, but from the fishing industry, which is one of the foremost clients of the Ministry of Agriculture, Forestry, and Fisheries.

In the final analysis, it is not difficult to see how wind power is a greater challenge to the system than solar. Granted, solar needed the support of the bureaucracy to overcome vested interest resistance. At the same time, resistance has dwindled, as the utilities have gradually come to accept solar as part of the energy landscape, and especially post-Fukushima, as solar has been perceived as essential in the quest to close the gap in electricity production resulting from the disappearance of nuclear power. Yet, it is also important to remember that solar is still a small player. The Koizumi administration's strong market focus was one reason for the 2005 removal of the subsidy. And while PV has sometimes been referred to as METI's 'pet', the utilities and the nuclear village have always been far more powerful and influential. This may have changed somewhat since Fukushima, and growth in solar PV will most likely remain rapid for years to come. Yet, as METI's pet, there has never been any doubt that METI is the owner. METI is in charge, the pet is not.

Fukushima: disaster and window of opportunity

For the past four decades Japanese energy policymaking has been mostly gridlocked, with no internal dynamic triggering change. In 'Vested Interests, Energy Efficiency and Renewables in Japan' (Moe, 2012), which was submitted only a few months before Fukushima, I suggested that realistically, substantive change could only come about as a response to one of two potential external shocks. One would be international pressure, making Japan feel a need to bring out major new policy for fear of negative universal exposure or embarrassment. The other would be a natural disaster in close proximity to a nuclear power plant, resulting in a critical reactor leak and radically changing the attitudes of the media and the public.[24] In 2011, the latter tragically happened, as on March 11, a 9.0 magnitude earthquake resulted in a giant tsunami that swept ten kilometers into the country and knocked out the Fukushima Daiichi plant on northern Honshu.

The immediate effect was for all of Fukushima's 12GW of generating capacity – more than 20 percent of Japan's nuclear capacity (roughly 49GW) – to be shut down. Since then, for prolonged periods of time, all of Japan's nuclear reactors have been down for repairs or maintenance, or for sheer safety reasons, depriving Japan of pretty much its entire nuclear capacity. Rolling blackouts were avoided in the summer of 2011, but only because of the public's exemplary compliance with a host of power-saving measures, as electricity consumption dropped by 9 percent compared to 2010 (RenewableEnergyWorld, 2011). While it seems likely that some nuclear plants will be phased back in, capacity will never again reach pre-Fukushima levels. Even prior to the earthquake and consequent tsunami, METI's vision to increase the share of nuclear electricity from 30 to 50 percent seemed far-fetched, for the simple reason that local resistance ever since the mid-1990s has made it exceedingly difficult to install new plants. Thus, nuclear, both in terms of total nuclear electricity generation and of percentage of total electricity generation peaked in 1998 (Midford, 2014). Not surprisingly, since Fukushima, support for nuclear has kept dwindling – there has been no knee-jerk reaction, but rather a slow and steady walk – changing a stable majority for nuclear power into a stable majority against. An *Asahi Shimbun* exit poll from the day of the 2012 lower house elections revealed that only 15 percent opposed any phase-out of nuclear. Notably also only 14 percent wanted an immediate phase-out. However, an overwhelming 78 percent were in favor of either an immediate or an eventual phase-out. Among LDP voters, 43 percent opposed the no-nuclear option in any form, and the LDP was the only party not to promise to phase-out nuclear (Midford, 2014; Umbach, 2014). It seems unlikely that Japan will start constructing entirely new nuclear power plants, for all practical purposes, phasing-out nuclear in the long term no matter what. However, with the present LDP government some idle nuclear capacity will probably still be phased back in (*Power*, 2014d).

While renewables will certainly benefit, they are not the short-term solution. The supply gap in the summer has been somewhere around 16GW, and as of today, renewable energy cannot fill this gap. The argument has also been made that without nuclear, it will be impossible for Japan to fulfill its climate commitments. Indeed, since Fukushima, Japan has withdrawn from the Kyoto Protocol and it has shelved the 25 percent GHG emissions reduction pledge made in 2010 by former Prime Minister Yukio Hatoyama (Umbach, 2014).

However, external shocks can also create windows of opportunity. It is still far too early to predict what the final outcome of Fukushima will be, but there is no doubt that energy policy is subject to a very serious rethink. The obvious question for a book like this is whether or not this will be good for renewables. In one way, the answer is obvious and boring. With 30 percent of the electric generating capacity gone, this will mean an upswing for all other power sources. The immediate result, however, is that Japan has increased its LNG imports by more than a quarter (95 percent of Japan's gas demand is met by LNG imports), resulting in the share of natural gas in net electricity generation rising from 30 percent in 2010 to 43 in 2013 (*EIA*, 2015; Frei, 2012). And Japan was already before 2011 the world's biggest importer of LNG (and the third biggest net importer of oil). And because LNG import prices have risen by a full 38 percent, LNG costs have increased from ¥3.5 trillion to ¥6.5 trillion. Thus, with nuclear gone, Japan in 2012 experienced its first trade deficit since 1980 (partly also because some of the main export industries were doing badly).[25] Faced with a shortfall of energy and expensive LNGs, one of the consequences of Fukushima could even be a considerable increase in coal consumption. From 2010 to 2013 coal has increased its share of electricity generation from 24 to 30 percent, and Japan now actually has 13 GW of new coal-fired power generation in development (Adams, 2012; *EIA*, 2015; Ernst and Young, 2012a; Fairley, 2014; Frei, 2012; Terashima, 2012; Umbach, 2014).[26]

One genuine improvement that will probably come out of Fukushima is the breaking up of the electric utilities and the unbundling of electricity generation and transmission. For renewables, especially wind power, the fact that the utilities could essentially physically shut renewable power out of the grid was a major problem. The utilities have been totally against unbundling, but are far weaker politically than they used to be, not only because of Fukushima but also because of the effective nationalization of the largest and most powerful of the utilities, namely TEPCO, which in 2012 received a ¥1 trillion (approximately $8 billion) injection of government-backed money to prevent its collapse.[27] But in 2012 METI recommended unbundling, and the LDP government of Shinzo Abe, traditionally very close to the utilities, pledged its support to this recommendation. Thus, a nationwide power-grid operator will be created by 2015 and the electricity retail market will be liberalized by 2016. The consumer market will be deregulated by 2018, whereas full unbundling of electricity transmission and distribution is set to happen by 2020 (Ernst and Young, 2013a; *Guardian*, 2012; *Japan Times*, 2013; Midford, 2014; Umbach, 2014). While a clear improvement over the present situation, the effects could to some extent be undone by the utilities forming holding companies that control both generation and transmission. Thus, while the vested interest structure gave in on unbundling, it was by no means stripped of all its power and influence (Katz, 2014).

That said, and gloominess and cynicism aside, energy policy is no longer the preserve of technocrats associated with the 'nuclear village'. Changes have certainly taken place and Fukushima has made the collusion between the utilities and the regulator, and the ease with which the utilities got away with regulatory fraud, abundantly clear. In essence, the state regulatory committee responsible for reviewing the nuclear plants was itself a member of the 'nuclear village' and thus a part of the vested interest structure upholding the hegemony of nuclear. No inspection of nuclear plants had been held for seven years. Only two months before the tsunami, the committee granted the oldest of the Fukushima reactors a ten-year extension of its lifespan, beyond the normal 40-year operational limit. Thirty-three pieces of cooling and diesel generator equipment had not been controlled, the regulators instead giving in to TEPCO lobbying. Previous requests to make upgrades had simply been ignored by TEPCO, and already in 2003 TEPCO had admitted to falsifying records to cover up major safety incidents. But in addition to the regulatory committee being part of the same vested interest structure as the utilities, in 2012 it was also revealed that links between the utilities and politicians were exactly as close as many had suspected. Both TEPCO and the other utilities funneled major campaign contributions to the LDP, and 70 percent of individual donations to the LDP political management fund stemmed from present and former utility executives. Evidence suggests that the donations were explicitly coordinated by the utility companies (Midford, 2014; Umbach, 2014).

This reveals the extent to which energy policy had been subject to a vested interest structure controlled by the 'nuclear village', with both the regulatory authorities and the LDP in very close cahoots with the utilities. Now that this is becoming public knowledge, it shows the strength of the energy interests that renewables have had to rise in opposition to. However, it also suggests a brighter future for renewable energy, in the sense that at least a somewhat more level playing field can now be expected.

Among the reasons for this are decisions of former Prime Minister Naoto Kan to strip METI of some of its responsibilities. For instance, the Diet, rather than METI, now appoints the members of the committee that sets the FIT (although there are loopholes in this arrangement), and he also stripped METI of its nuclear safety responsibilities, instead setting up an independent Nuclear Regulatory Agency (NRA). Stringent safety tests devised by the NRA will need to be passed for any nuclear plant to be phased back in. This for all practical purposes rules out cheap or speedy restarts. At the time of writing, all reactors were down. A couple had been expected to be restarted before the end of 2014, but despite the NRA approving the restart of four reactors (Sendai 1 and 2, as well as Takehama 3 and 4), local resistance and court injunctions have slowed the process down, and so far no restarts have happened. In the past, Japanese courts would have been very reluctant to meddle in what was seen as the prerogative of the bureaucracy and the legislature, but after Fukushima, the judiciary has taken on greater importance in the sense that for every plant that is approved for a restart by the NRA, anti-nuclear lawyers have stated an intent to file injunctions, a possible indication of the weakening of the nuclear village (*Reuters*, 2015; *wnn*, 2015). Thus, irrespective of who is in power, it has become far harder for the utilities to restart the nuclear plants, as they are now subject not just to substantial new safety regulations and considerable public skepticism, but also court battles. However, as with most new implementations, the devil is in the details, and in this case, there are both a few details and some potential devils. The NRA comes under the MOE and its five-member panel is selected by the politicians. In 2014, two NRA commissioners ended their tenure, one of whom was highly anti-nuclear. Of the two new members, picked by the pro-nuclear Abe administration, at least one is quite pro-nuclear. Thus, questions are being posed about the future independence of the NRA (*Japan Times*, 2014b; Midford, 2014; *Reuters*, 2014e; Umbach, 2014; *wnn*, 2014; *World Nuclear Association*, 2014), and while the vested interest structure is undoubtedly weakened, the Abe administration is considerably closer to the 'nuclear village' than the DPJ is. Thus, the structural changes triggered by Fukushima may be in the process of being hollowed out.

Still, the lack of electric power should push solar PV development, irrespective of any nuclear phase-in. There will probably be no export-led growth or any revolutionary upswing for Japan's PV industry – China dominates the world market. True, the Japanese PV industry will grow from a generous FIT and from rampant domestic demand, but its global market share is low, and profit margins thin, even though Sharp and Kyocera are among the world's top ten manufacturers. That said, clean energy investments – mainly small-scale solar – increased by 75 percent from 2011 ($9 billion) to 2012 ($16 billion) and another 80 percent to 2013 ($28.6 billion). This is considerably more than Germany (although less than the US ($36 billion) and China ($53 billion)). The official PV target for 2020 has been doubled to 28GW, and if the present mood prevails, Japan should move beyond that target to 53GW by 2030 in a Japanese market that has moved from 1GW to 2GW and now to 10GW a year. Thus, there is certainly growth (EPIA, 2010, 2012; REN21, 2012, 2014; Vosse, 2014a).

As with nuclear, it is hard to accurately predict the future of renewables. Former Prime Minister Kan, for instance, declared that within 2020 renewables should account for 20 percent of electricity production. His successor, Prime Minister Noda seemed less thrilled, and while serving under Kan was one of several government ministers who declared that Kan's speech only represented his own personal views and that the idea of no nuclear reactors was merely the dream of one individual. What Kan, however, achieved, was the passing of a general FIT (August 2011) extended to all renewables (*asahi.com*, 2011a; *Bloomberg*, 2011; DeWit 2012a; DeWit and Kaneko, 2011; *Japan Times*, 2011c; *RenewableEnergyWorld.com*, 2011).[28]

The FIT is the most promising singular Japanese policy decision on behalf of renewables for decades. Originally set at ¥42/kWh (then lowered a number of times and as of July 1, 2015 standing at ¥27 for industrial and ¥33 for residential customers) the rates for solar PV were more than twice as high as in Germany and three times higher than in China, and with Japan now the second biggest PV market in the world, with installation figures 20 times higher than in the early 2000s, the initial effect has been huge (*METI*, 2015). The outgoing DPJ government targeted 20 percent renewable electricity within ten years and 30–35 percent by 2035, mainly through FITs, not just for solar and wind, but also for biomass and geothermal (which is an area in which Japan has an abundance of untapped power).[29] And the new 'Sunrise Project' aims at installing solar panels on ten million homes by 2020. The Noda administration advocated a full phase-out of nuclear by the 2030s, very much going against the utilities and Keidanren, which branded the plan 'unrealistic and unreachable' (*Japan Times*, 2012b). Others felt the plan had enough loopholes to be meaningless. However, since the demise of the DPJ, present Prime Minister Abe has made no determined challenge against Noda's plan. However, the 2014 Basic Energy Plan, while making the development of renewable energy a top priority (but without stipulating any targets), also signaled an end to Noda's nuclear phase-out, instead describing nuclear as a key base-load electricity source. If nuclear reactors can meet NRA safety tests, they will be phased back in (*Japan Times*, 2014a; Midford, 2014; *Power*, 2014d; Umbach, 2014). Thus, while energy policy is now to a far lesser extent subject to the constraints of the old vested interests, again we see the old structure regaining at least some of its power. In any case, METI, which still is the most powerful energy policymaking actor, has since Fukushima become less monolithic. And it has downgraded nuclear from the core of energy policy to one of three pillars, alongside energy efficiency and renewables. Both in name and in spirit, renewable energy is looked at in a far more positive light than prior to Fukushima (DeWit and Kaneko, 2011; *Japan Times*, 2011d, 2014a).

There are still a number of clouds on the renewable energy horizon. One of the main targets of the new FIT is the promotion of domestic industry and the strengthening of Japanese international competitiveness. However, since 2008 PV prices have fallen by 80 percent, and more so because of Chinese manufacturers flooding the market than because of technological improvements. This is a problem not just for Japan, but for all high-cost countries. The very generous Japanese FIT is at the moment in essence subsidizing large-scale Chinese imports as much as stimulating the domestic PV industry. The cost of PV panel imports rose from around ¥100 billion in 2011 to almost ¥600 in 2013 and a projected ¥940 (approximately $8 billion) in 2014. This is a lot of money, and it is bound to only keep increasing. The domestic industry will certainly also benefit, but if the FIT is set so high that it triggers similar PV boom-and-bust cycles as we have seen in Europe (most notably in Spain and Italy, but even in Germany),[30] a Japanese bust will leave the low-cost Chinese manufacturers standing while making life for high-cost Japanese manufacturers very difficult (Asano, 2012; Caldecott, 2013; Ernst and Young, 2012a, p.30; Huenteler et al., 2012, p.9; Vosse, 2014a, 2014b).

A bust is not unlikely. From a record 10GW of installations in 2014, they will most likely drop somewhat in 2015. This is not a surprise, as 2014 was an extremely good year, with developers rushing to take advantage of the high FIT before rates were lowered. But beyond that, the underlying dynamics have an uncanny resemblance to the situation in Germany (see Chapter 5), which must be a worry. In Germany, a generous FIT in combination with rapidly falling PV prices made installations increase so fast that they ran way ahead of grid expansions. Also, the steady accumulation of installations soon made the FIT very expensive. This resulted in Germany reining in PV growth from 7GW per year to no more than 2.5GW. In comparison, the Japanese grid is in a far more precarious situation than the German, as mentioned earlier not connected to the grids of any other countries, and divided into ten monopolies with only weak interlinkages. Feeding large amounts of renewable energy into such a grid will lead to problems. Granted, the power of the utility companies is a huge part of the reason for the state of the Japanese grid in the first place – the interlinkages are weak by design – thus this is a blatant manifestation of vested interest power. But no matter who is to blame, one consequence is that the grid is far less suited to coping with large amounts of intermittent renewable power than the German grid. And as installations are running ahead of capacity here as in Germany, utilities have cut back on their purchases of renewable energy – not as in the past only of wind power, but also of solar PV – claiming that they lack the capacity to feed it all into the grid, or imposing grid-upgrade fees that make renewable projects economically unviable. Thus, grid access is rapidly becoming the biggest obstacle for renewable energy developers. Further, as the Japanese FIT is even more generous than the German once was, there is little doubt that it will become expensive, and (and as in Germany) the increased costs have led electricity prices to soar, up by 20 percent for homes and 30 percent for businesses, in a country where electricity was already expensive. A potential backlash can also be seen within METI, where the initial enthusiasm for renewable energy is souring. In 2015 a METI subcommittee estimated that by 2030 20 percent of the energy will be provided by renewables. But this is the same figure that also appeared in the Basic Energy Plan from as long ago as 2001. This is for all practical purposes an indication that METI is starting to feel scared by the projected costs and political difficulties of building facilities for transmitting electricity produced by renewables, and that it is scaling back its ambitions. Thus, the utilities, which had clearly been weakened by Fukushima, are seeing their influence growing again (*Economist*, 2014h; Fairley, 2014; *Japan Times*, 2014c, 2015).

Regardless of this, what is also striking, is how much bigger the enthusiasm for PV is than for wind, which remains on the outside. PV is projected to account for 80 percent of the installed renewable capacity over the next decade (so far 96 percent of the renewable energy concessions that have been granted have been for solar), and while the FIT has undoubtedly been good for renewables, it is telling that the solar FIT was far higher than the wind power FIT, which currently stands at ¥22/kWh (although a separate ¥36/kWh FIT for offshore wind has now been introduced) (*Japan Times*, 2014c; *METI*, 2014a). But as mentioned earlier, the renewable expansion since Fukushima has been almost exclusively about solar, and the long-term installation targets for wind are quite modest.

Energy expert Paul Scalise has long predicted a fierce battle over nuclear and renewables. While Fukushima has contributed to rapid deployment of renewable energy, Scalise warns that the main problem may easily be transmission and distribution and that improving the grid will require major investment, which will lead to protracted fights with local governments (Scalise, 2010). In the short term, LNG will be the biggest winner. TEPCO already has 25.8GW of gas-fired generating assets. This is the quick and dirty stop-gap solution, and the politically easy one. It also lends itself to the continued dominance of the utilities. Thus, the crisis could be a window of opportunity for renewables, leading to the gradual phase-out of old nuclear plants, no replacements being built, and the power gap filled by thermal, and gradually renewables. But it could also reinforce and recycle the same forces and structures that enabled the crisis. Energy policymaking power is still located within METI (and the MOF). This is realistically where attitudes toward nuclear and renewables must change before energy policy will (DeWit and Kaneko, 2011). Still, in the words of Umbach (2014, pp.62–3), '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.'

Conclusions

It could be that change in Japan was underway already before Fukushima. There are indications that the utilities were gradually becoming more cooperative and favorably disposed toward PV. And change was certainly underway in one, significant respect: For the past decade and a half, NIMBY-effects had made it almost impossible for politicians to install new nuclear capacity, and even before then, the side-payments required for any local communities to accept nuclear power were getting extortionate. And so, METI's pre-Fukushima vision of a 50-percent share for nuclear electricity was probably already then utopian (or dystopian). With a projected life span of 40 years for a nuclear power plant, most plants would have been phased-out by the 2030s regardless.

Still, until the earthquake and tsunami, for four decades the structure of Japanese energy policy had been fairly remarkably stable, with attitudes toward renewables virtually unchanged: The focus on solar as the only renewable energy source of interest and the disregard for wind have persisted; the preference for nuclear has been stubborn; the power of the utility companies and their close relationship with METI remained constant; and today METI still sits at the hub of energy policymaking.

Taking as our vantage point the assumption that countries with ambitious renewable energy policies are countries with unsolved energy-related problems, the fact remains that even with large unsolved energy-issues Japan only partially conforms, and more clearly than most countries, demonstrate the importance of taking vested interests seriously. For decades these have been strong, and consequently energy policy has been gridlocked.

Institutional support has ensured that among the renewables, solar is the insider. 'Very little seems to have changed over the past three decades in the relative emphasis placed between the different forms of alternative energy' (Luta, 2010). The preference for solar is about both energy policy and industrial policy. Government support has been reasonably steadfast. The relationship with the utilities has gradually improved. The industry has enjoyed lobbying success, and has some policy influence. Its growth has occurred without much change to the existing institutional and industrial structure. On the contrary, the major solar players were major industrial players before solar came to the fore. Solar enhanced the competitiveness of already existing industry rather than challenging it. Thus, while vested interests may stifle the growth of new industry, success comes far more easily when the newcomer can grow within the existing framework. Even the new comprehensive FIT has an inbuilt preference for solar.

Solar could hardly have succeeded without government programs following the 1973 oil crisis and support at several subsequent critical junctures. Up until Fukushima, the onus was still overwhelmingly on nuclear, fossil fuel imports, and energy efficiency. Solar was a minor player and, in terms of installations, Japan was surpassed by Germany, and more recently China, with Sharp losing its position as the world's biggest PV producer. The FIT that was introduced in 2009 was a belated, half-hearted FIT implemented by a bureaucracy that did not believe in its usefulness, and it took until Fukushima for a comprehensive FIT to be pushed through. However, increased international competition means that the renewed *industrial* success of Japanese PV is not ensured. The adoption of far more ambitious targets for 2020 means that PV is being installed at a rate never seen before in Japan, but much of this could easily end up being imports from China. And it might not be overly popular if the end result of this policy is that instead of stimulating Japanese industry, the government and Japanese electricity customers end up subsidizing Chinese imports at a huge cost to Japanese taxpayers. Moreover, this happens in a country that has essentially endured two-and-a-half decades of economic stagnation and where the national debt is higher than in almost any other industrialized country. Thus, while solar is expanding at unprecedented rates, economic realities suggest that in the future, tough political priorities on renewables may very easily have to be made.

While solar is partly on the inside of the vested interest structure and enjoying major growth, wind power is the ultimate outsider and decidedly on the outside. It gets little media attention, has virtually no lobbying or political influence, no support groups inside METI, and enjoys little goodwill from the utilities, which up until now have had the power to decide whether or not to allow wind onto the grid. Unbundling will change this, but compared to solar, wind was disadvantaged from the start as possibilities for commercialization seemed worse. With solar, a number of discrete products readied for market and for consumption by individual households could be envisaged. For wind this was less so. For Japanese wind turbine producers, the best strategy up until now may well have been to ignore Japan in favor of the international market. The 2009 FIT did not include wind, and even if this was changed in 2011, 80 percent of the projected renewable growth will be in PV. So far, the new FIT has not yielded any increase in wind turbine installations.

It is well beyond doubt that vested interests are at the heart of Japanese energy policy. Also, the different extent to which solar and wind are embedded in the vested interest structure explains much of their relative success. Solar, working mostly inside the existing industrial and institutional structures, has fared reasonably well and received ample government support for prolonged periods of time. Wind, which by far poses the bigger challenge in terms of structural change, has been left more or less to fend for itself.

Although weakened, METI is still at the hub of Japanese energy policymaking. But it is important to remember that METI is no monolithic structure, and that greater changes to Japanese politics have happened over the past couple of years than for decades. Energy policy had remained stale, stable, and firmly in the hands of a vested interest structure that pre-Fukushima seemed little weaker than before the DPJ came to power vowing to combat it. In Fukushima, Japan however, suffered its biggest external energy shock since 1973. Devastating as it was, it has also provided energy policymaking with a window of opportunity. It has allowed for a comprehensive FIT. And during an administration that pre-Fukushima would most likely have been highly pro-utilities, the LDP administration of Shinzo Abe, a bill on the unbundling of electricity generation and transmission was passed, against the opposition of the utilities. And so, the old vested interest structure has definitely been weakened by the shock that was Fukushima, creating a more level playing field for renewable energy, at least for the near future. Shocks to the economy is exactly what Joseph Schumpeter is about, and Mancur Olson would easily agree that the more entrenched and rigid the economy is, the bigger the shock required to bring the country onto a new trajectory. There will still be a lot of politicking about Japan's energy future, and there are major infrastructural problems to be overcome, such as a grid network that is in need of very serious overhaul and investment. Thus, it is too early to tell if Fukushima will end up being a blessing in disguise. But early signs are positive, and while there are some indications that the Abe administration is phasing nuclear slowly back in, hollowing out the changes triggered by Fukushima, it is unlikely that Japan will completely reverse course. While there is certainly still life left in the old vested interest structure of the Japanese energy-political economy, it has also been severely weakened since 2011, providing considerable optimism for the prospects of renewable energy, and especially so for solar PV.

3
China: No Energy Transformation, but Full Speed Ahead. Or…?

Introduction

No country has grown faster over the past few decades than China. And no country has more rapidly increased its energy consumption. China is now both the planet's foremost energy consumer and its foremost CO_2 emitter. Fairly abundant in a number of natural resources, domestically mined coal has been the solution to most of China's energy challenges up until fairly recently. Coal still accounts for 64 percent of primary energy consumption, almost 80 percent of the electricity generated, and at 47 percent of world total, China is the biggest coal consumer in the world (Andrews-Speed, 2012; Bloch et al., 2012; *China Daily*, 2015b; Karlsson, 2012; Zhang et al., 2013a). There is, however, also a growing realization within the Chinese leadership that few countries will be hit harder by global warming, through floods, droughts, and air pollution (e.g. Wang, 2010; Zhang et al., 2013a). While major transformation to the Chinese energy structure has yet to happen – and is probably also far away from happening – a dramatic expansion in renewable energy has been among the Chinese responses to both its energy and climate challenges.

With major unresolved energy issues, and fairly abundant in certain renewables, we should expect China to be a frontrunner in the development and implementation of renewable technology. In terms of sheer capacity, it certainly is. With 430GW of total renewable power capacity at the end of 2014, of which 145GW is wind and solar, China comfortably leads the world (the US is second, with less than 200GW of total renewable capacity (*China Daily*, 2015a; REN21, 2014).

In wind power China more or less doubled its capacity for six years in a row up until 2010, at which time it surpassed the US in terms of total installed capacity. With a present installed capacity of 115GW, which may easily increase to beyond 200GW by 2020, China is certainly leading the world in this respect. In solar PV, the story has been a different one. For many years, PV for all practical purposes existed only as an export industry. China is by far the biggest PV producer and exporter in the world, with more than 60 percent of the global market and hosting most of the planet's largest solar companies. However, it is only in the past few years that growth in *domestic* PV installations have picked up, at least in part triggered by economic crisis and reduced market opportunities in Europe. Thus, in only a couple of years, the domestic market has gone from negligible to the biggest in the world. The goal for PV installations is now 70GW within 2017, up from a current 30GW (2014) (*EPI*, 2014; GWEC, 2015; Liu et al., 2011; Liu and Goldstein, 2013; *pv magazine*, 2014b; REN21, 2014).

Renewable energy is certainly being taken seriously. In targeting wind power as one of the growth industries to bolster it through the present global economic crisis (Wang, 2010; Zhang et al., 2010), China explicitly targeted a renewable energy industry as a new growth sector. In fact, among the 'new strategic and emerging industries' singled out in the 12th Five-Year Plan, we find both wind and solar (as well as biomass, clean-energy vehicles, high-speed rail, energy-saving, but also nuclear) promoted to replace the 'old pillar industries', including coal and oil (Lewis, 2013). There certainly is evidence that Chinese leaders have consciously sought to promote renewable energy industries as part of a strategy to upgrade its industries and change its industrial and energy structure. While this is no easy task and one that meets with lots of friction, results have been impressive, and they have been fast. Renewable energy was never really on the policy agenda until 2005, but following extensive reshaping of the regulatory framework (2005–06), as well as a number of amendments (2009), progress has been very rapid.

While this is all good and fine, in many ways it is also something that one should almost expect. First, China has both major energy needs and an abundance of sun and wind. Second, economic growth has been exceptionally strong for a much extended period of time. Energy demand keeps soaring, and is projected to keep rising – by 45 percent between 2009 and 2020 (Zhang et al., 2011). And third, it can easily be argued that until now China has primarily been picking low-hanging fruits. Despite impressive growth, between 2005 and 2007, renewable electricity capacity as a share of total electricity capacity actually fell. In 2012, the share of solar *and* wind (and biomass) energy to total electricity was no more than 2.5–3 percent (GWEC, 2014, p.18; NEA et al., 2013;

REN21, 2014, p.58), as opposed to 39 percent by wind in, for instance, Denmark, and more than 50 percent in four German *Bundesländer* (China is, however, not so far behind the US (4.5 percent), and it is ahead of Japan). Coal will remain the dominant source of energy for decades still to come (Andrews-Speed, 2012; Liu and Kokko, 2010; REN21, 2014; Wang et al., 2010; Zhang et al., 2010). Between 2005 and 2010, the share of coal in the energy mix even increased, from 69.5 to 70.0 percent (and up from 61 percent in 2000) (Andrews-Speed, 2012). Admittedly, this is not much, but what it does mean is that despite very rapid growth in renewables, the pattern that can be observed is not one of an energy *transition*. Little genuine structural change has occurred. Rather, the pattern is one of more energy, from all kinds of sources, and of energy efficiency, where China is still lagging behind.[1]

What does this tell us about vested interests in the Chinese renewable political economy? First, it tells us that it is hard to know! While impressive improvements have happened, as long as no major structural change is occurring and everyone keeps growing, the state does not have to make political decisions that to any major extent go at the expense of existing vested interests. And so, while it is hard to judge for sure the real strength of Chinese vested interests, it is also hard to know what the real potential is both for growth within renewables and for genuine structural change in the energy structure.

This is not to say that nothing has happened. It clearly has. The 11th Five-Year Plan (2006–10) explicitly targeted a 20 percent reduction in energy intensity, and despite economic growth far exceeding the original projections, 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). And in 2014, for the first time since 2001, Chinese carbon emissions even dropped – by 2 percent – mostly because of a reduction in coal consumption. Granted, these are preliminary figures, and the reliability of Chinese official statistics has sometimes been less than impressive, but coal demand is certainly slowing, which suggests that change may be afoot (*Bloomberg*, 2015d; *Climateprogress*, 2015). Future targets are impressive, fueled by several factors – climate, energy and industry: First, there is the increasing realization that China is one of the countries that will be hit the hardest by climate change. Second, energy security is currently quite high, but is unlikely to remain so unless China can considerably ramp up its renewable energy production. And third, there is clearly a perception in Beijing that these are potential growth industries, and that there are major industrial and economic spoils to be had for China (Lewis, 2013; Wang, 2010; Zhang et al., 2010).

Thus, one of the things that this chapter reveals is steady growth in wind and accelerating growth in solar. On the face of it, China is headed for the sky in terms of renewables with no vested interests halting progress. Government support has been strong and steadfast, at least since 2005. Ernst and Young (2013d) holds China, with the US, to be the best country in the world for renewables (across a number of indicators). At the same time, while the immediate future is rosy, there are obvious challenges ahead. The two biggest ones have to do with the underdeveloped grid network and the lack of coordination between different actors and different branches of government, where the opacity of the system makes it very open to abuse. When looking more closely at these challenges, we find networks of actors and interests, and the main reason why these have so far all been kept reasonably content is that growth has been so strong that there has been something in it for everyone. The open question thus is: What happens when China is no longer growing rapidly enough to prioritize everything (and thus essentially prioritizing nothing)? What happens when China needs to start making tough choices in its energy policies? While there have only been minor vested interest problems up until now, these are challenges that will require difficult decisions involving numerous powerful actors with overlapping areas of responsibility. There are enough powerful actors within Chinese energy politics that the future is nowhere near settled yet. In a future where Chinese growth rates can no longer keep everyone happy, there is certainly a major potential for vested interest problems. As this chapter will show, there are definite signs that this may be happening already.

Wind power

While pre-Fukushima Japan seemed lukewarm on renewables, and heavily influenced by vested interests (see Chapter 2), the very opposite was the case in China. While the interest of the state in renewable energy is recent, there is little doubt that it is firmly behind this expansion, and prospects for wind have been bright for quite some time.

Prior to 2005, renewables was not a major policy issue. Granted, China has a history of wind going back at least to the 1970s and as such is one of the earliest countries to have sought to industrialize wind energy. The first wind farm was connected to the grid in 1986, and renewable energy was given a first explicit mention in the 1995 electricity law, in which the state would encourage and support electricity generation from renewable and clean-energy sources (Han et al., 2009; Wang, 2014; Xu et al., 2010; Zhang et al., 2010). Yet, prior to 2005, wind turbines were either very small or pilot projects only. And by 2003, China was nowhere close to fulfilling its 1GW wind power target. The year 2003 was, however, also a first turning point. That year the VAT on wind power was halved to 8.5 percent and a number of duties reduced or removed. But while capacity doubled between 2003 and 2005, it was only with the 2005 Renewable Energy Law (REL) that wind power took off, with installed capacity more or less doubling every year for the next six years. Goldwind is today one of the biggest turbine manufacturers in the world, and Sinovel and Mingyang are also in the top ten. The REL obliges the grid companies to purchase wind power, which means that at least on paper, China has emulated some of the most successful recipes from other countries, such as Germany, and this has been crucial. Granted, it is not obvious that the grid companies have a strict legal obligation to purchase wind, but more on that later.

Starting in 2003, the Wind Power Concession Program introduced a tendering system whereby power companies would bid for concessions provided by the central government. While this system worked well enough in the sense of stimulating competition, it had glaring weaknesses. In a country dominated by SOEs (state-owned enterprises), budget restrictions are often soft.[2] And when wind power concessions typically go to the lowest bidder, there is a serious potential for underbidding. This potential for underbidding has been accentuated by the fact that the state has actively promoted the development of local wind turbine manufacturers. There are now more than 80 of these (up from only six in 2004), and so the supply of wind turbine units has greatly outstripped demand. This has had two consequences. First, if a power company receives a concession that it cannot fulfill because it underbid, it will underinvest in the wind farm, as it does not have the financial resources to construct and operate it at the price of the bid. Second, since SOEs have laxer budget restrictions than private firms, including foreign companies, they can underbid more seriously. Ninety-seven percent of the concessions have gone to SOEs (Gosens and Lu, 2014; 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).

The weaknesses of the concession program became ever more obvious,[3] and in 2009 it was for all practical purposes abandoned, giving way to something resembling a FIT, whereby the country was divided into four regions with government-set benchmark prices. This should at least in principle reduce market entry barriers, and initial impressions were favorable (Liu and Kokko, 2010; Zhang, 2010; Zhang et al., 2010). The Chinese wind power market has a few peculiarities. The halved VAT was criticized as stimulating imports rather than domestic production and R&D. Thus, tariffs were raised on smaller turbines, leaving tariffs low on large turbines where China is lagging technology-wise. While the market is dominated by SOEs, the technology gap means that foreign multinationals have been relied upon for the largest turbines. Chinese wind power is still dependent on importing technologies and systems and suffers from a lack of qualified researchers and engineers. However, the days when China depended on foreigners for most of its wind power progress is long gone. Chinese manufacturers entered the global wind market scene relatively late, and hence they all originate from either a licensing deal or a partnership with a foreign manufacturer. However, where only ten years ago the foreign share of wind power equipment was 75 percent, in 2014 domestic manufacturers controlled 98 percent of the market (*CleanTechnica*, 2015; Gosens and Lu, 2014; REN21, 2014; Zhang et al., 2013b). The average size of Chinese turbines still lag behind leaders such as Denmark, but Sinovel has produced a 5MW and Mingyang a 6MW turbines. There has been talk about 10MW turbines, but this seems like political propaganda more than anything else, as politicians are pushing for China to demonstrate technological leadership, even where none exists.

The old and established SOEs have been able to draw upon a history of manufacturing in heavy machinery, electric power generation equipment, and aeronautics. However, turbines produced by smaller firms (also SOEs) do not have the same technological, efficiency, or utilization levels. These firms supply the market for smaller turbines, and are protected by tariff barriers. And for the very largest turbines, multinationals such as Vestas, Gamesa, Suzlon, and GE have set up operations in China, and are dominating the market. Thus, even after a decade of very rapid progress, most domestic turbines are small and not very competitive, with weak technical expertise. The domestic turbines are also less reliable, and the wind power industrial chain still not as complete as in Europe. Also, despite rapid progress, there has been limited innovation in the Chinese wind power industry. Chinese firms are still not on a par with Western companies, and quality control is an issue. Thus, while the Denmark chapter (Chapter 6) reveals a worry that Denmark is no longer ahead of the game in terms of wind power development, China is not the country that Denmark is falling technologically behind. Rapid expansion has resulted in quality problems, even from producers such as Sinovel, Mingyang, and Goldwind (Hu et al., 2013; Klagge et al., 2012; Wang et al., 2012).[4] There have been concerns (e.g. Wang et al., 2012, p.87) that the present innovative capacity is not enough to sustain the industry, and that a shortage in human capital is becoming ever more evident. What is telling is that despite hosting three of the world's top ten wind turbine manufacturers, they all rely almost exclusively on the home market, and unlike solar PV, are not at all export oriented.[5] This could obviously be because the home market is growing so fast that exports are essentially unimportant for Chinese companies. This is, however, not the case. In 2011, China installed almost 18GW of wind power capacity. This was far more than any other country in the world. But production of the Chinese wind *industry* exceeded 30GW, in other words rendering 40 percent of the production capacity idle. In 2013, the gap between production capacity and domestic market demand had grown further to an estimated 36.5GW (Gosens and Lu, 2014). Thus, the lack of exports actually matters, and is a clear indication that quality and technological sophistication still lags behind.

Despite the above, there is no doubt that progress has been extremely rapid, and that Chinese wind has become ever more competitive – to such an extent that in 2009 local content requirements were scrapped, no longer protecting local producers. Turbine prices in China fell by 35 percent between 2008 and 2012 – a result of oversupply, but also of increased competition in the Chinese market and of technological improvements. The oversupply may lead to the market consolidating. Still, growth is expected to continue at a very rapid pace. Projected targets have been beaten time and again, and at 115GW as of the end of 2014, the installed capacity has long surpassed the projected 2007 target of 30GW by 2020. It has now been ramped up to a more challenging 200GW by 2020 and 1000GW by 2050. In 2012, the market temporarily slowed to the extent that China marginally fell behind the US in terms of newly installed capacity. However, this was partly because of stricter approval procedures, Chinese authorities responding to the long evident quality and safety problems. Thus, in 2013, Chinese installations bounced back. At 16GW it amounted to 45 percent of the world total that year, and the record-breaking 23GW installed in 2014 accounted for 45 percent that year as well. Moreover, the first offshore farm was constructed in 2010. For now, 24 offshore wind farms have been approved. With a projected potential of 550GW it is not inconceivable that offshore wind will provide 50 percent of the electricity needed in the coastal regions by 2030. This is, however, one area where developments are falling behind schedule. So far, less than 1GW have been installed, and the 2015 5GW target will not be met. A target of 30GW has been set for 2020, but siting issues are causing serious delays. China is the first country to install offshore turbines in intertidal zones, which brings challenges that other countries have not faced or solved. Security concerns have led to foreign companies (with greater technical expertise on offshore wind than China) being kept out. And finally, the lack of a an established pricing mechanism is another serious problem – there is as of yet no established FIT for offshore (Gosens and Lu, 2014; GWEC, 2015; Hong and Möller, 2011; Hu et al., 2013; Korsnes, 2014a; Lewis, 2013; Liu and Kokko, 2010; REN21, 2014; Ru et al., 2012; Zhang et al., 2010; Zhang et al., 2013a; Zhao et al., 2012; Xu et al., 2010).

Solar power

In Japan, solar power was the pet project of the METI, with wind very much neglected. In China, it has been the other way around. Until recently, solar PV has fallen in the shadow of wind power. Based on geography and weather, there is no reason why China would not have near unlimited possibilities within solar. Granted, the growth of the Chinese PV industry has been extremely rapid, but up until recently it was focused more or less exclusively on exports, with consumer products for domestic use accounting for a very small share of its activities.

Technology and timing are two simple reasons why solar has needed, and received less, support than in Japan. First, compared to wind power, the technological entry barriers in solar PV have been far smaller. This was not so 30 years ago, when Japan started spending major amounts of money on solar. But by now technologies are fairly familiar, and compared to wind, production is labor- and energy- rather than capital intensive. This may be in the process of changing. The speed of technological progress is picking up with innovation and product differentiation becoming more important, and China certainly lags behind the competition in terms of quality and technological sophistication. Still, up until now it has been possible for Chinese companies to reach international competitiveness fairly easily and with low labor costs, China can supply the market at prices that are 20–30 percent below those of its European competitors (Zhang et al., 2012; Zhang et al., 2013b). Thus, currently nine of the world's top 15 PV manufacturers are Chinese (REN21, 2013a). China hosts a well-developed PV industrial chain with more than 50 solar cell and 300 solar module companies, and has abundant resources of quartz sand and silica. By 2013, Chinese companies controlled 60 percent of the world market for solar PV cells (64 percent for solar modules), up from only 3 percent as late as 2004 (see Figure 3.1). From only 40MW in 2004, Chinese production in 2010 surpassed 10GW, then doubled the next year, to more than 20GW. This happened without much direct policy support (EPIA, 2013; *GTM Research*, 2014; Roney, 2010).

Second, the timing of events was fortuitous. In the mid-2000s, a number of European countries instituted generous FITs at more or less exactly the time that Chinese producers were scaling up their production and becoming competitive. This coincided with then market leader Japan scaling down and ultimately removing its solar subsidy. Thus, European markets, in particular the German, but also the Spanish and Italian, suddenly proved hugely beneficial to Chinese PV, with 90 percent of the solar cells exported abroad. Ninety-five percent of the

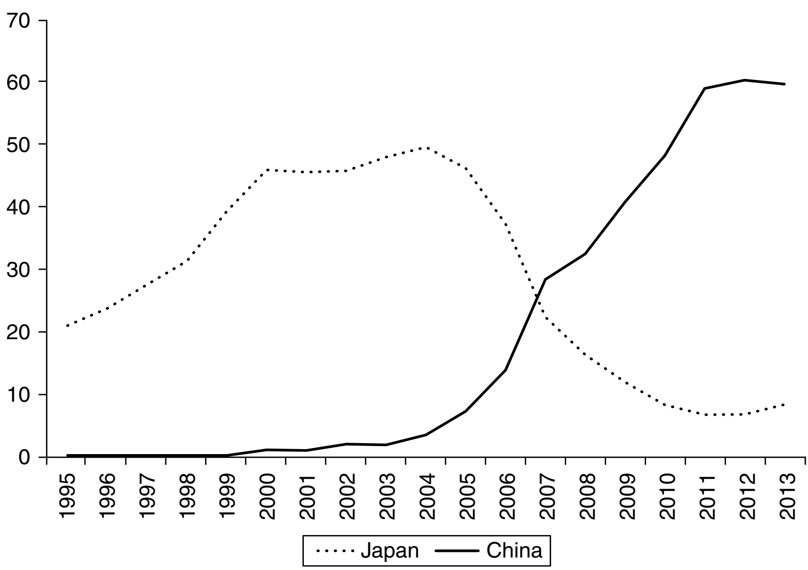

Figure 3.1 Solar PV cell market share, 1995–2013

Sources: Figures calculated by *EPI* from *GTM Research* (2014).

revenues of previous market leader Suntech Power were derived from markets outside of China (Liu and Goldstein, 2013; Yergin, 2011, p.580; Zhang et al., 2012).

However, the financial crisis hit Europe hard, and European demand for Chinese products dropped. The combination of Chinese oversupply and a slowdown in European demand has had some beneficial effects. For instance, it has led to PV prices dropping by 80 percent over only a couple of years. It also led to China changing its perspective on PV. Until the financial crisis, PV was seen as an export industry only, not a source of domestic energy supply. But flagging European demand led to the realization that foreign dependence means vulnerability. And the reduction in European installation subsidies led to a re-installment of the export subsidy, and to the creation of a domestic market.[6] From 2008 to 2014, installed capacity increased more than 200-fold, from 145MW to 30GW. A future target has been set for 70GW by 2017. With the domestic market already beyond 10GW per year, this target is within reach. The changes to these targets are in themselves evidence of the shift in Chinese PV policy. Thus, in 2007, the 2020 target was only 1.8GW. By 2009, it had been increased to 5GW by 2015 and 20GW by 2020. And as mentioned, it was recently shifted upward again, to 70GW by 2017, despite the fact that only a couple of years earlier it had been increased to 50GW by 2020. And so, China now not only has the largest domestic PV market in the world, but will soon also surpass Germany to have the largest capacity. If targets are met, China will in four years add more capacity than the entire world had installed up until 2011 (*EPI*, 2014; EPIA, 2012, 2013; Ernst and Young, 2013b; Grau et al., 2012; Huo and Zhang, 2012; Liu and Goldstein, 2013; *pv magazine*, 2014b; REN21, 2012; Wang, 2010; Zhang, 2010; Zhang et al., 2011; Zhao et al., 2011).

True, Chinese PV benefited less from government support than wind, but as European demand exploded from 2004 onward, central and local governments provided strong support, seeing this as an opportunity to foster major growth. Thus, in the provinces, local PV companies were given preferential treatment, cheap loans, easy access to capital, financial support for R&D, and export credits and guarantees. But since the cost of PV was far higher than the cost of wind, besides 1990s rural electrification schemes, little emphasis was put on fostering a domestic market. This did not change until 2009. As the domestic PV industry wilted under the effects of the financial crisis in Europe, export woes and defaulting domestic industry were major triggers behind the initiatives to create a domestic market. Thus, in

2009, the Solar Roofs and the Golden Sun programs were initiated. The former subsidized capital investments in PV, whereas the latter was a program supporting demonstrations of key technology. Equally importantly, the National Energy Administration (NEA) initiated a FIT for solar, with concession bidding for large-scale on-grid projects. In addition, the Ministry of Science and Technology (MOST) supports R&D in universities, research institutions, and firms. Still, public budgets for R&D in PV are minuscule compared, for instance, to those of Germany and the US, and far behind Japan as well (Grau et al., 2012; Huo and Zhang, 2012; Zhang et al., 2014).

The success in PV exports and the rapid development of the domestic PV market does, however, contain a few pitfalls. The programs that were initiated in 2009 to stimulate PV growth have led to a massive government-supported investment boom.[7] Production of PV cells increased eight-fold in only two years. The Chinese PV industry now contains more than 2000 companies, and Chinese PV production capacity has at times exceeded total global consumption by 50 to 100 percent (Zhang et al., 2013b; Zhang et al., 2014). This imbalance is an obvious problem. Thus, despite nine out of the 15 biggest PV manufacturers being Chinese with global market shares of 60 percent and upward, the situation is far from completely rosy. PV prices dropping by 80 percent has hit foreign manufacturers harder than the Chinese. But Chinese companies are not shielded against competitive pressures. In 2013, Chinese giant and then market leader Suntech Power went bankrupt, demonstrating the vulnerabilities even of Chinese companies. Some Chinese manufacturers may effectively have been losing $1 for every $3 of sales in 2012 (*New York Times*, 2013). This inevitably leads to bankruptcies. Nearly all of China's several hundred solar firms are losing money (*Economist*, 2013b), but not everyone is struggling as hard as Suntech. This is because the industry has seen a bit of a last-mover advantage. Early entrants such as Suntech signed long-term fixed-price contracts for silicon when it was far more expensive – it has dropped in price from beyond $400/kg in 2008 to a recent low of only $16/kg. Thus, late comers have lower costs. But, as can be seen from Figure 3.2, a number of major Chinese PV manufacturers incurred hefty losses already in 2011, including current market leader Yingli. US reports suggest that total debts accumulated by China's top ten PV makers have reached a pretty astonishing CNY111 billion (or almost $20 billion) (REN21, 2013a; Zhang et al., 2013b).

The industry is ripe for consolidation, not just worldwide, but very much in China as well. But this only reluctantly happens. Bankrupt

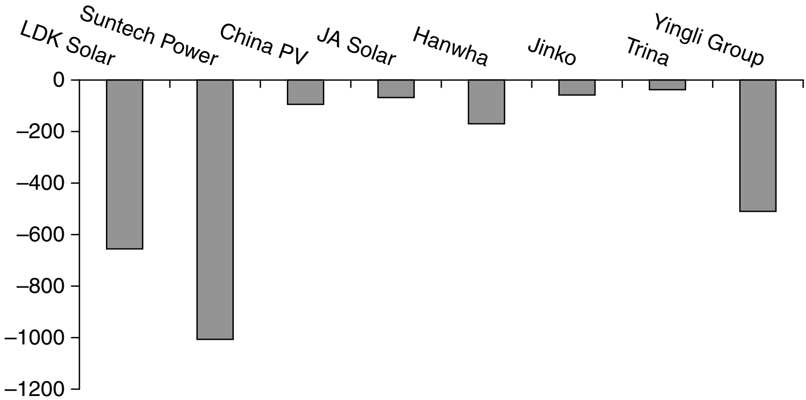

Figure 3.2 Chinese solar PV manufacturers' financial losses in 2011 (million $)
Source: Wang (2014).

Suntech Power was quickly bailed out by the city government of Wuxi, and local government has helped out LDK Solar (which was once among the world's ten biggest manufacturers) and Chaori Solar Energy. Samuel Yang the chief executive officer of Hareon Solar (another top ten manufacturer) – one of the newer and more prosperous Chinese solar companies – laments that no one is doing well, and that everyone is 'locked in the prison' (*Reuters*, 2013b). Overcapacity is bound to keep causing problems, even with the new and very ambitious PV targets.

This brings us to the root of a potentially huge future problem (and a minor present one): The reluctance to let dead companies go bankrupt. In Chinese solar, there has been no Schumpeterian moment. This could be a consequence of growth having been so rapid that no such moment has seemed necessary, as subsidies and bail-outs can still be afforded with relative ease by the authorities. But it could also be a consequence of the onus put on social harmony and a fear of lay-offs causing social unrest. While there may be a growing (albeit reluctant) realization within the central government that bankruptcies are an inevitable part of the future, local governments are more afraid of stoking social unrest. They are also extremely anxious not to lose jobs (Suntech's main factory in Wuxi employs roughly 10,000) and investments. And they realize full well that bankruptcies will do great harm to local creditors, which is where much of the funding for these companies came from. But relying on solar demand to solve the problem is also a perilous strategy. Growth in Europe has stalled and growth in China still depends on subsidies.

These create a demand for solar PV, but the subsidies will have to be reduced in the future, as the system is already under pressure. Ironically, the capacity may have to shrink for the industry to keep growing, and if companies are also not allowed to go out of business, there is no pressure on them to become technologically more sophisticated (*Economist*, 2013b, 2013c; *Reuters*, 2013b).

Thus, far more so than in wind power, market consolidation and bankruptcies are a necessary part of the solar future. Ernst and Young (2012b) in 2012 predicted that 54 Chinese solar module companies would crash by 2015 (and 180 worldwide), and 50 Chinese manufacturers actually did go bankrupt – a sign that the state is no longer willing to protect every small solar zombie. In a landmark case, in March 2014, Chaori Solar became the first Chinese firm to default on a debt in the bond market. It looked as if the firm would be allowed to go bankrupt, a clear sign of the willingness of the authorities to start letting moribund firms go under. However, in a surprising move half a year later, Chaori Solar was allowed to restructure its debt, having been bailed out by nine companies forming a joint venture in which the presence of the government was very evident. Thus, at the first sight of trouble, China prioritized stability over reform, telling investors that there is no credit risk, as major companies will not be allowed to default (*Reuters*, 2014f; *Wall Street Journal*, 2014a, 2014b). In general, the bigger solar companies have all been granted loans at favorable conditions, as mentioned before amounting to almost $20 billion from Chinese state banks (REN21, 2013a).[8]

In addition to this, both the US and the EU have accused China of dumping. Thus, in 2012, the US imposed a 31 percent tariff on 61 Chinese solar panel manufacturers, and 250 percent on another group of PV companies. The EU first announced provisional duties of 37.3–67.9 percent, before imposing a lower anti-dumping tax, and a trade war was eventually averted by the tax being replaced by minimum prices and quantity limits. This could actually be a good compromise for China. It provides its main manufacturers with a guaranteed and fixed minimum price, increasing the profit margins of the Chinese manufacturers, and possibly allowing the government to allocate European market shares to its main manufacturers, thereby squeezing more of the zombies out of the market and contributing to consolidation within China. Thus, Chinese solar may be about to have its first Schumpeterian moment, but one forced on it from abroad, or rather it may use the EU as an excuse to undertake policies that will consolidate the industry (*Economist*, 2012a; Ernst and Young, 2013c, 2013d).[9]

Vested interests?

So, what does the above tell us? China has had storming success in both solar and wind, and despite clouds on the horizon, renewable prospects seem better than almost anywhere else. Government support has been strong, and energy demand keeps increasing. In Japan, the different treatment of solar and wind has had much to do with how the two have been positioned within the government apparatus and the institutional structure. The vested interest structure has favored solar over wind. But China does well in both solar and wind. Both are steadfastly supported by the government and considered strategic industries for the future. The obvious and immediate conclusion seems to be that in the Chinese system, vested interest problems have been averted.

The reality is more complex. For a number of reasons it is hard to gauge the actual strength of Chinese vested interests. China may be a market economy, but one of the legacies of the Communist Party is that it is still – to a far larger extent than Western economies – characterized by command and control than market mechanisms, as well as heavily populated by SOEs. Also, the institutional structure is opaque, with overlapping jurisdictions and areas of responsibility. The PV industry consists primarily of private enterprises, but SOEs account for the large majority of Chinese energy actors, including wind power where they represent 80–90 percent of installed capacity. In wind power, the state is heavily involved: It commissions wind power projects, it operates wind farms, and it produces 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 vested interests actually are, or how strong they are. One could obviously conclude that because the state is so heavily involved, the whole vested interest problem has been eliminated, and that the success that has been achieved is proof of this. Perhaps the state – a strong, communist state, which does not get gridlocked by political parties or by politicians afraid to displease the voters – has found a kind of economic-industrial rationality that Western economies can only hope for, eliminating interest battles, and preserving its independence. But this would be wrong. There are numerous weaknesses with the Chinese system, and there is good reason to believe that of the future problems of the Chinese state and renewables vested interest problems will be among the most prominent. And there is evidence that these problems are already becoming notable.

The first point here is that in some ways China is not so different from Japan. The often widely praised (and sometimes ridiculed) Japanese bureaucracy has numerous policy divisions. METI is no neutral actor, and its relationship with select industries is close and protective. But there is no good reason why an economy consisting of SOEs would have a substantively different relationship with an otherwise very opaquely institutionalized system. Instead, one could easily argue that the plethora of SOEs with lax budget restrictions make inefficiencies more glaring, the relationships with the state more incestuous, and even more based on personal relationships (rather than profit calculations) than elsewhere. Banks know that it is 'safe' to lend money to SOEs. Within the state sector there is no perception of risk. And so, it is far easier for SOEs to attract funding than it is for private actors, leading to a bias in the direction of low-quality, state-owned projects. With personnel going back and forth, tending toward a harmony of interest between state and industry, there is no reason why the Chinese system makes for a political economy in which industrial decisions were more rational and less biased than, for instance, in Japan, rather the other way around. The energy companies certainly have political influence, especially in the provinces, but being the leader of an energy company is often used as the starting point for a political career, thus the leader will also seek to be attentive to party politics and to politicians. While this is to some extent conjecture, what we know both from China and from other countries is that this is an environment in which vested interests often thrive, and where mobility, institutional flexibility, and openness to change is replaced by an order that shelters the actors that are already on the inside of the system at the expense of those on the outside (e.g. Acemoglu and Robinson, 2012; Ferguson, 2012; Korsnes, 2014b; Moe, 2007, 2009b; North et al., 2009).

Second, the SOEs dominating Chinese wind are not primarily wind power companies. Instead, they are regular power companies (relying on coal, petroleum, and nuclear), which have branched out into wind because the state forced every power generation company to have a certain amount of non-hydro renewable power (6.5 percent on average by 2015) in its energy portfolio (Tsinghua-MIT, 2013). This is different from Japan, where wind power companies have suffered from being in direct competition with the utilities. Thus, conceivably, being part of a bigger company, renewable energy could be sheltered from the forces that it has been exposed to in Japan. But the effect could also be the opposite. If energy companies accept wind only because the state makes them, as a plight and not as a business opportunity, this easily leads to the utilities only fulfilling minimum requirements rather than pushing developments. Thus, while the largest power companies had a 3 percent mandatory renewable capacity target for 2010, only half of them complied, and there were no penalties for non-compliance. And on numerous occasions – since the SOEs control the entire wind sector – because of their laxer budget restrictions, SOEs have underbid non-state owned competitors, often to such an extent that the winning tender price has gone below normal profits rates, leading to low-quality installations as a way of salvaging profits from the wind farm (Tsinghua-MIT, 2013; Zhang et al., 2013a; Zhao et al., 2013).

The third point is that while Chinese wind power installation figures are highly impressive, Chinese renewable electricity generation is less so. A few years ago, as much as 30 percent of the installed capacity sat idle, not being connected to the grid. This is now down to around 15 percent, but this is still a lot, for instance when compared to the US, which has no off-grid capacity at all. And because China has not yet closed the technology gap to the West, the operating efficiency for Chinese wind power is less than half of that of the US. Thus, we should not paint a rosier picture than can be justified. In 2011, both the US and China had 47GW of *grid-connected* wind power (China also had 15GW of unconnected capacity). From this, China produced 74TWh of electricity. The US, on the other hand, got 120TWh out of its 47GW (Denmark is also head and shoulders above China in this respect, with 13TWh from less than 5GW of capacity) (GWEC, 2013; Liu, 2013; Schuman and Lin, 2012; Wang et al., 2010; Zhang et al., 2013a).[10] In other words, with an installed capacity a fourth lower than China, the US produced over 60 percent more electricity. The US advantage has shrunk somewhat, but still persisted. Hence, China in 2013 generated 138TWh compared to 167TWh in the US. 2014 saw record installations, but because the productivity of Chinese turbines actually fell, the capacity increase was almost entirely offset by productivity reductions. And so, despite China having a capacity of 115GW compared to 66GW in the US (end of 2014), the US keeps generating 20 percent more electricity from its turbines. For both wind and solar, installed renewable *capacity* has grown faster than renewable *electricity generation* (AWEA, 2015a, 2015b; *CleanTechnica*, 2015; Zhang et al., 2013b).

There are several reasons for this. One is that the windiest areas, such as Inner Mongolia, are also among the most scarcely populated and with the most notoriously weak grid connections. However, the geography cannot take sole responsibility. One particularly striking example is from Jilin province in the northeast where the nearest city is 300km away from the wind farm, and the nearest 220kV line 150km away. This is indicative of a general problem in Chinese renewable energy policy. China has given much attention to state-of-the art, large-scale turbines, but poor integration between the wind (and solar) farms and the grid is a huge obstacle to future growth. Partly, this is because of provincial autonomy, not to say obstinacy, taking advantage of a system that rewards installed capacity rather than electricity generated. China has capacity targets, not generation targets. Thus, installing extra capacity has often been more important than the actual generation of electricity. To add to that, the grid is simply not very well-developed – a consequence of China still being a developing country and beyond the Pacific coast overwhelmingly rural. Thus, another reason why China is number one in wind power capacity, but only number two in electricity generation is curtailment, that is, wind power output that exceeds the capacity of the transmission grid to transfer the electricity, and which is thus essentially spilled. State Grid struggles to transmit power from major renewable energy areas to the population centers on the coast because of a lack of a comprehensive high-voltage and smart grid (*Reuters*, 2013b; Wang et al., 2012). The 2009 amendments to the REL are meant to improve the grid connection of wind power, and the NEA in 2011 added regulations to prevent wind power curtailment (Lewis, 2013; Schuman and Lin, 2012). Thus, there is a definite awareness of these problems. Still, in 2011, curtailment in the northwest reached almost 35 percent, and overall curtailment rates have been rising, averaging 16 percent in the country overall, which is far higher than, for instance, in the US. The dominance of coal is one reason for the high curtailment rates. Coal-powered plants are not very flexible in adjusting their output, and thus tend to hog the grid, and so, while on the surface vested interest problems may not be particularly severe, and while renewable electricity is strongly backed by the central government, this is one area in which wind power consistently suffers and where the political power of coal makes it hard for China to get the most out of its wind resources. The top ten wind provinces in 2011 lost a total of 6TWh as a result of curtailment. Thus, the political economy of Chinese renewables still leaves much to be desired (REN21, 2013a; *theenergycollective*, 2013c).

This leads to a fourth and related point, which supports a suspicion that the embrace of wind and solar from the power companies and the grid companies is rather half-hearted. With most of the wind resources in the north and northwest and the major population centers in the east and southeast, transmission challenges are formidable, especially with a distinctly subpar grid system. But compared to Japan where up until recently the utilities could essentially shut renewables out of the grid, the 2005 REL specifies that in China renewable energy has priority access, and that the grid company has to bear any financial losses from connecting renewable energy to the grid. It obliges the grid companies to purchase wind power and the power companies to supply it. This has been crucial, and without it, grid companies would most certainly have resisted renewable energy as in Japan. However, despite the REL, there are 'few regulations and instructions on how to connect wind power to the grid' (Zhao et al., 2009, p.2887). Wang et al. (2010, p.1875) state that 'it is commonplace for grid enterprises to refuse or delay building or expanding grids to connect to renewable power plants'. And 'until the effective lack of regulation ... is rectified this mandate [to purchase electricity from renewables] will remain meaningless' (Wang, 2014). There have been no reported cases of penalties imposed on the grid companies for refusing to comply with the REL. Some renewable plants have instead ended up building grids themselves. Thus, grid companies have been very reluctant to fulfill their obligations and a number of power companies and grid companies have not met the designated targets. The main concern, as in so many countries, is that renewable electricity fluctuates to such an extent that it destabilizes the net. Thus, State Grid has been holding back on its purchases of renewable electricity because of intermittency concerns, even if it has explicitly avowed that all renewable energy will be connected for free.

The grid companies have also been reluctant to invest in transmission infrastructure. The monopoly of the State Power Corporation was dismantled in 2002, resulting in five state-owned power generators and two grid companies. In essence, the two grid operators are still de facto regional monopolies. A law mandating the two grid operators to produce 15 percent of their electricity by renewables is being drafted (Ernst and Young, 2013a), which will be a major improvement for renewable energy producers, but without any market competition, the grid companies have no incentive to expand the grid: Building infrastructure is costly, most renewable plants are located far away, and renewable energy is costlier than coal-based electricity, thus renewable energy reduces the operating profits of the power companies.[11] A fourth of all renewable projects are delayed in connecting to the grid. Even FIT subsidies have typically been delayed by six to nine months after the electricity has actually been generated and sold. Thus, the grid companies and the transmission infrastructure may easily be the biggest barrier against renewable expansion, and as in Germany (Chapter 5) and currently in Japan (Chapter 2), the grid and transmission infrastructure expansion is not keeping up with the pace of wind and solar expansion. A unified power grid network is not scheduled until 2020, and at present, China for all practical purposes consists of seven independently operated grids. China is however also building the world's largest ultra-high-voltage transmission system to connect its remote wind-rich northern and western areas to the metropolises along the coast, This should also alleviate some of the curtailment problems (Jiang et al., 2010; *Reuters*, 2013b; Roney, 2015; Schuman and Lin, 2012; Wang, 2010; Wang et al., 2010; Zhang, 2010; Zhang et al., 2013a). It is quite evident that vested interests are present in China too, and while in terms of structures, institutions, and political systems it is not at all similar to its easterly neighbor, China would still feel quite familiar to any student of Japanese energy policy.

Fifth, China is to a far greater extent than Western countries still characterized by command and control. The trend certainly is in the direction of more market, but until now the weaker market focus has had the consequence that targets are for *installation* rather than electricity *generation* (or for that matter electricity *utilization*), as witnessed by the curtailment rates and the large proportion of off-grid installations. So, as mentioned, China gets far fewer TWh out of its installed capacity than the US. This is in the process of changing. Power quotas for electricity *generation* are now being implemented, which is a large step forward as it provides incentives to *generate* electricity, but can only happen if the grid companies actually connect and transmit the installed capacity (Schuman and Lin, 2012; Zhang et al., 2013a). However, jeopardizing this is the fact that communication between the central government and the provinces is pretty much bereft of bottom-up input. Thus, old-fashioned command and control is typical of the way in which goals and targets have been imposed on the provinces, with little guidance as to how they should be fulfilled. This has given provincial authorities considerable leverage in implementing central directives, sometimes with distinctly dysfunctional effects. One example is the 50MW loophole, whereby until 2011 wind farms smaller than 50MW only require local approval. This led to 49.5MW wind farms popping up in the most unlikely places, not particularly efficient because of the small scale, but also often off-grid as gridlines have not been planned, and with larger wind farms split into 49.5MW components and thus made less efficient than they otherwise would have been (Schuman and Lin, 2012; Wang, 2014; Zhang et al., 2013a).[12]

There have been other consequences, too. The high volume of subsidies has stimulated mass installations. But little of the money is flowing into innovation. Policies are geared toward boosting capacity, not stimulating technological progress. And the lack of an explicit technology focus means that China is lagging in terms of R&D. As mentioned earlier, despite major forward leaps, there is limited innovation in Chinese wind power, as well as quality issues and technical problems with domestically produced wind turbines. This is partly about poor planning and oversight and collusion between political and economic elites, but also about poor craftsmanship, a low-skilled workforce, and a lack of technical expertise (Hu and Xu, 2013; Klagge et al., 2012; Wang et al., 2012). A similar shortage is evident in solar. China lags behind in the most sophisticated solar technologies,[13] as well as in production technologies, even if catch-up has been smoother here than for wind. Also, there have been concerns about the quality control of Chinese PV modules as well as with the lack of clear technical standards (Ernst and Young, 2013d; Lewis, 2013).

There is also a cost issue. The focus on capacity and the fact that growth in renewables is heavily dependent on subsidies means that success is becoming ever more costly. Subsidies for renewables (wind, PV, biomass) are paid for through a surcharge on electricity levied on consumers. In 2006, it was CNY0.001/kWh, but by 2013 it had reached CNY0.015/kWh (Tsinghua-MIT, 2013). This is still not enough to cover the expenses of the subsidy, and the shortfall increased from CNY1.4 billion in 2010 to CNY22 billion in 2011, and will only keep increasing unless the FIT comes down or the surcharge goes up. Some estimates suggest CNY80 billion (approximately $14 billion) by 2015.[14] Between 2002 and 2008, wind power subsidies increased 17-fold. And while government backing is strong, this can hardly continue forever. This is also because so far subsidies have overwhelmingly gone to wind. But, with PV now rapidly expanding, and with a higher FIT than wind (0.51–0.61CNY/kWh for wind vs. 0.90–1.00 for solar), expenses will accelerate. Subsidies could be cut for solar farms. However, in 2013, the government instead introduced a 50 percent tax break on the sale of solar power. This shows how serious China is about reaching its 2017 target of 70GW. It also means that China is planning to keep spending serious money on renewables. The Chinese solar FIT does, however, not include a tariff degression formula, unlike in most Western systems. Instead, it simply states that the government will adjust the tariff based on changes in investment capital and technological improvements. This makes for a lack of predictability (Ernst and Young, 2013d; Hu et al. 2013; Jankowska, 2014; *Reuters*, 2013b; Schuman and Lin, 2012; Tsinghua-MIT, 2013).

Sixth, and finally, the institutional structure is opaque. Energy regulation in China is inherently confusing and highly politicized. Responsibilities are overlapping, authority is diffused throughout the system, and there is a lack of clarity with respect to the interpretation and implementation of energy measures. Thus, as Korsnes (2014b, p.180) points out, 'therefore, a change in energy policy amongst top-level leadership does not equate to smooth implementation throughout the system'. There is plenty of room for bureaucratic in-fighting and to vested interests playing institutions against each other and hiding inefficient policy away inside an institutional structure that defends the status quo without being able, or willing, to adapt to changing circumstances. China most likely needs a Ministry of Energy in order to unify and coordinate laws and regulations on energy production, conversion, distribution, consumption, and pricing. This it does not have. Instead, in 2008, a bureaucratic reorganization led to the formation of an Energy Bureau, headed by a government minister as well as an Energy Commission. These jostle for power and responsibility with the NDRC (National Development and Reform Commission), SERC (State Electricity Regulatory Commission), and the energy companies. The reorganization represents an improvement, but it is unlikely to have energy policy coordination problems disappear. There is also NEA (National Energy Administration), which is the only state-level institution specializing in advanced wind power technology and equipment. However, the five major power generation companies and the two grid companies have as much influence as NEA, and they often pursue their own agendas, as we have seen plenty of examples of also in other countries, see for instance the Japan chapter (Chapter 2). In addition to these, MOST, CMA (China Meteorological Administration), MEP (Ministry of Environmental Protection), and MOF (Ministry of Finance) are involved in areas such as R&D, demonstration and deployment, wind and solar resources assessments, environmental assessments, and financial incentives of renewable energy deployment.[15] In addition, regardless of the central government, national decisions are locally implemented. And so, there have been an array of coordination problems between the national and the local level. Granted, the 2009 REL amendment dealt with some of this, but one consequence of this opaque institutional structure is that provincial authorities are left with lots of leverage, often pursuing goals that are in conflict with those of the central government, and consequently resulting in lots of barriers for renewable developers. Between 2003 and 2011 90 percent of the wind farms were approved by local governments, which perceived of wind power as an easy way to boost the local economy. This led to applications being granted very quickly, to rapid growth in installations, but also to many of the problems regarding lack of coordination and low quality described earlier in this chapter. It is only since 2011 that all wind projects have to be approved by NEA (Jiang et al., 2010;

Korsnes, 2014b; Schuman and Lin, 2012; Wang, 2014; Zhang et al., 2013a; Zhou et al., 2010).

The leverage is used in a number of ways. Even in the absence of national vested interest battles, it may easily be a problem at the provincial level. For instance, local governments typically allocate generation quotas to the power plants. However, thermal plants increase local revenues more than wind power, which is the weaker player. Thus, thermal power companies tend to lobby for increased generation quotas at the expense of the allocation left for renewables. And on days when the power load is low, the thermal generation quota is the one that gets prioritized, leaving less room for renewable power generation. This essentially sets a guaranteed floor for coal generation. It would take major policy change for the prospects of renewable energy to improve, and such a change would explicitly go at the expense of the power of coal. In its battle to preserve the status quo, coal would also have numerous provincial governments on its side. One solution would be to sell surplus renewable power to other provinces. However, there is strong competition between provinces, resulting in very little electric power trade. Accepting wind power from elsewhere is seen as undermining local economic growth. Thus, while growth in wind power is strong and solidly backed by the central government, at the local level we do not have to scratch far beneath the surface before we find serious vested interest battles (*theenergycollective*, 2013b; Zhao et al., 2013).

Despite these six points, there is no arguing that China has exhibited a very different attitude toward renewables, wind power in particular, than most countries. The rapid expansion has very much been due to deliberate government policy. But what the above suggests is that vested interests are important here as well. It is hard to gauge their exact strength, for the reason that economic growth has been so strong that growth in renewables has bordered on the inevitable. There is little doubt that the lack of a well-functioning grid is a serious problem, even if impressive installation figures serve to disguise this fact. And there is little doubt that there are serious differences of interest with respect to the construction of a national grid network. Zhang et al. (2013b, p.343) refer to 'immense grid connection problems' and to 'ever-growing amounts of curtailed wind generation'. The division of authority and responsibilities between half a dozen agencies, the only partial and belated introduction of market mechanisms, and the fact that national laws have to be locally implemented, means that there is generous room for vested interests to influence politics. And unless political action is taken, these problems are likely to persist and grow: first because renewables will keep growing at a very brisk pace, exacerbating the already existing frictions, and second because it is unlikely that Chinese growth will remain at their current stellar levels for all eternity: In a world where Chinese growth is decreasing (it already may be), so that China can no longer essentially prioritize everything, interest battles will become fiercer and more pronounced, and genuine policy-choices will have to be made. China has powerful energy industries (such as coal), and as in other countries, these have typically put their stamp on national energy policies, and have often become very concrete obstacles to energy reform and to the rise of alternative (and competing) sources of energy (e.g. Sovacool, 2009b; Moe, 2010, 2012).

Still, the proof is in many ways in the eating of the pudding. It is hard to attack Chinese renewable energy policies when the end result has been as impressive as it has, and in such a short amount of time. Even in solar PV, which for long was an export industry only, China now has the largest domestic market in the world. Granted, the renewable expansion has to a large extent been driven by steadily increasing demand for energy rather than a purposeful attempt at structural change, but growth both in wind and solar has accelerated following government attempts to improve the regulatory and institutional framework, vested interests or not. The point I am making in this chapter is not one of whether it is easier to cope with vested interests in a country dominated by the state (or a Communist Party) than by private actors. But the Communist Party, the prevalence of SOEs in the Chinese political economy, and the reliance on command and control rather than market mechanisms, make for a very interesting difference with all the other countries examined in this volume. And while one might easily hypothesize that the state in a non-democratic country, such as China, has more leverage and can act more decisively, especially when the industrial actors are somehow also owned by the state, opacity does not normally make for good governance. 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 open to easy abuse. It is normally a more fertile breeding ground for vested interest influence than a more open system.

Structural change after all, or just more of the same?

On the one hand, no country installs more renewable energy than China. On the other, China is the world's largest emitter of CO_2, the world's biggest producer and consumer of coal, and expanding its capacity of coal faster than any other country. Thus, there is a highly schizophrenic quality to Chinese energy policy. President Xi Jinping has called for an energy revolution, and Premier Li Keqiang has declared war against pollution (*China Spectator*, 2014; *Guardian*, 2014a). The question then is to what extent the rhetoric is for real and structural change is actually happening, or if what we are essentially seeing is just more energy, irrespective of whether it is renewable or not.

The promotion of renewable energy has been a major component to Chinese energy policy ever since the introduction of the REL in 2005, and there is little doubt that China is serious about renewables, which in addition to the promotion of wind and belatedly solar has also included major hydropower expansion.[16] The REL set targets for renewable energy production, mandated compulsory grid connections, introduced a FIT, introduced cost-sharing for electricity generated from renewable energy, and established a renewable energy promotion fund. The 2009 revisions to the REL has emphasized a more scientific approach to renewable energy planning, tidying up problems with respect to securing free and guaranteed grid connection for renewables and enhancing the financial incentives for renewable energy development (Wang, 2014). The fact that China in the 12th Five-Year Plan lists both solar and wind as 'new strategic and emerging industries', set to replace the so-called old pillar industries, is certainly a good sign. Among the old pillar industries we find both oil and coal. These have long benefited from government support and are largely state-owned. Thus, this signals an ambition for structural change as the old pillar industries are supposed to be phased out in favor of the new strategic and emerging industries. What can at least be expected is that industrial policy, access to capital, R&D funding, and so on will be biased away from the old industries and toward the new and emerging ones (Lewis, 2013).

To some extent this is borne out by policy. Renewable energy policy in China started out as industrial policy, with an eye to energy security. Focusing on the relationship between China's renewable energy policy and China's renewable energy *industrial* policy, Zhang et al. (2013a) supports this view by asserting that China always prioritized the developing of new renewable industries over the actual deployment of such equipment domestically. PV started out as an export industry only, and for wind, the onus has been on installations rather than generation.

Installed capacity running ahead of demand is typically a sign of bad planning. However, Zhang et al. (2013a) argue that this was always the plan, or something that was at least not considered a problem. The main purpose was to restructure and upgrade Chinese industry and to leapfrog the competition within industries that the Chinese leadership perceived as growth industries of the future. Thus, production capacity, installations, and the capturing of foreign markets was a higher priority than deployment. Focus has explicitly been on installed capacity rather than electricity *generation*, and Zhang et al. (2013b) even claims that priority access to the grid was introduced not to accommodate renewable energy, but to stimulate renewable energy *investments*. With PV, the purpose of the programs that were put in place in 2009 was to save Chinese PV manufacturing. True, it led to a formidable expansion of the home market, but this was an effect of the policy rather than a cause. The industrial development idea always outranked the notion of green development. What this, however, means is that within the Chinese leadership there has been a strong emphasis on structural change, as China has purposefully sought to develop industries it considers strategically important, and as it is deliberately trying to shift its production toward more high-tech, high-value added industries.

Over the past few years it has, however, become ever clearer that renewable energy is also seen as part of an air pollution, green industry and technology development, energy intensity, and carbon emissions strategy (Liu and Goldstein, 2013; Zhang et al., 2013a; Zhang et al., 2013b; Zhang et al., 2014). The 12th Five-Year Plan targets a reduction in the share of coal from 70 to 62 percent of total primary energy supply and a reduction in carbon intensity by 40–45 percent by 2020. The latter may sound more purposeful than it really is. According to Delman and Odgaard (2014) China will improve its carbon intensity by 44 percent simply by continuing existing policies. Thus, China is already well on its way to fulfilling its target. And there is evidence that the original plan was for reductions of 50 percent, which was then scaled down before the 2009 Copenhagen Climate Change Conference (COP15) so as to make the target more easily achievable (Delman and Odgaard, 2014). Evidently, there are still enough low-hanging fruits that very significant reductions in energy intensity can be had simply by employing the most advanced technologies available.

The biggest obstacle to an energy transition is, however, coal. No country installs more coal power than China. In 2011 alone, coal plants with a total capacity of 55GW were installed – more than twice as much as the total non-hydro renewable capacity installed, and accounting for 87 percent of the world's increased coal consumption that year. True, older and less-efficient plants are phased out, thus between 2006 and 2011 85GW of small, inefficient generation were closed down (IEA, 2013b). This obviously merits praise. But for each of those years, far more capacity was phased in than out, thus the net effect was a rapid increase in capacity. Over the next 15 years, China may add as much as 343–450GW – more than the entire US fleet of coal plants (*Bloomberg*, 2013a). Also, the expected life span of any new coal plant is 40 years. Thus, China is essentially locking-in new capacity that will remain in place for decades still to come, perpetuating Unruh's (2000) notion of a carbon lock-in, and conceding more power to some of the already most powerful actors of the Chinese vested interest structure. The new plants are certainly not meant as backup load for renewable energy. Thus, one should take any notion of a structural change with at least a few grains of salt (Bloch et al., 2012; *Climateprogress*, 2013; IEA, 2013b; Karlsson, 2012). The Chinese leadership is sincere in desiring structural *industrial* change, as in becoming successful within the growth industries of the future. But this does not necessarily entail an *energy* transition. For that, renewable energy would have to displace fossil fuels, rather than just becoming successful export industries, which is a far harder task.

There is, however, a lot of uncertainty when it comes to guesstimating the fortunes of Chinese coal, which could easily be good news for renewable energy. For long, peak coal in China was not expected until the 2030s at the earliest. But over the past few years reports have documented a considerable slowdown in the growth of coal consumption, preliminary data even estimating that in 2014 – for the first time in this millennium – coal consumption actually dropped, by 2.9 percent (*Bloomberg*, 2015d; *theenergycollective*, 2014a). Thus, peak coal could happen as soon as 2020. Others have pointed to what they see as overcapacity in the coal sector. However, while some argue that for the first time coal consumption and economic growth in China is now de-linked, others see the slowdown in economic growth as the main reason for the slowdown in coal, implying that no structural shift is imminent, and that what we are observing are just fluctuations in the business cycle. At this stage it is too early to tell, but coal demand is clearly slowing compared to all other sources of fuel (*Bloomberg*, 2013a, 2015a; *China Spectator*, 2014; *theenergycollective*, 2013b, 2014a, 2014c). Long-term projections suggest that by 2030 coal and renewable energy will be equal in terms of capacity (coal projected to rise by 25GW a year), but that coal will still supply 58 percent (down from 72) of the electricity as compared to 29 percent (up from 21) for renewable energy (including hydro) (*Bloomberg*, 2013a).[17]

Thus, while maybe no energy *transition*, there are signs of a change in the overall energy political direction. In the 12th Five-Year Plan three regions have instituted caps on coal production by 2015, at which stage China will possess the highest share of high-efficiency coal plants in the world. In fact, because of the rapid expansion of capacity in combination with the phase-out of old thermal capacity, Chinese coal plants, on average, are now more efficient than US plants. In 2012, for the first time, wind power generation increased more than generation from coal, and at more than 100TWh that year wind power output for the first time also exceeded nuclear power output. In 2013, China's new renewable capacity surpassed both new fossil fuel capacity and new nuclear capacity. And at approximately $65 billion, China in 2012 spent nearly twice as much as the US ($35.6 billion) on clean-energy projects. Renewable energy made up 20 percent of China's electricity demand in 2012, almost twice as much as in Japan. (Of which, however, hydropower accounts for 17.4 percent.) At the same time, in the primary energy mix (2010 figures) fossil fuels take up almost 92 percent (Andrews-Speed, 2012; IEA, 2013b; REN21, 2013a, 2014; *theenergycollective*, 2013b). Granted, this figure is on its way down, but at 92 percent, it has an awful long way to go before it makes much of a difference.

Both pilot carbon trading schemes and carbon taxes are being implemented. Beijing is on course for a national emissions trading scheme twice the size of that of the EU by 2020. For now seven pilot carbon markets have been set up,[18] and by 2016 a national market should be up and running. It is still early days for this scheme, and there are a number of legal and enforcement issues that need to be settled before this develops into an effective national system, but it signals an increased willingness to use market mechanisms and, if successful, can only be a good thing for renewable energy. Success, however, depends on China allowing the markets to work properly, which will be a major challenge to a country to such an extent characterized by command and control (*Climateprogress*, 2013; Jotzo, 2014; Zhang et al., 2014).

To the extent that we are witnessing structural change, we are very much in an early phase. Renewable energy is growing rapidly, but without making a huge dent in the existing energy structure. A true Schumpeterian energy moment will be very expensive and go against the interests of many powerful actors, especially within the coal industry. And as will be seen in the US chapter (Chapter 4), it could be that the most obvious transition so far is not one from coal to renewable energy, but from coal to natural gas, as in shale gas (and in natural gas imports). Currently, natural gas accounts for a smaller share of the energy mix than renewable energy (including hydro), but the hope has been for shale gas to double this share by 2020. China's reserves are the biggest in the world, well beyond those in the US. However, despite ambitious plans, the overall feeling is that China is still on the fence. Its most promising shale regions are remote regions where water – which is required in abundance for fracking – is scarce, and where the coal seams are deep and not particularly accessible. This is in addition to a number of institutional barriers as well as strong and monopolistic industrial interests controlling the pipeline infrastructure. Thus, fracking in China will be far more expensive than in the US, and fraught with at least as much politics. And so, the most recent development in Chinese shale is a slashing of the 2020 goals from 60–80 billion cubic meters to 30 billion.[19] In the short run, shale rivals neither coal nor renewable energy (*theenergycollective*, 2014b; Wan et al., 2014; Wang et al., 2014).

Jeopardizing any notion of a Chinese energy transition, energy policy is still bereft with inconsistencies and a lack of coordination both between the local and the central level and between different agencies. While Chinese efforts in reducing its emissions as well as its general efforts in cleaning up the environment should be taken very seriously indeed, the onus up until now has been on economic growth. This begs the question of what will happen to renewable energy once growth slows down. If economic growth is what drove it in the first place, then it is not obvious that it will keep growing (and implicitly at the expense of other energy providers) once growth dwindles. This is especially poignant with respect to local governments, which often have had only loose guidelines in implementing directives from Beijing. The power and influence of the coal industry also makes any abrupt shift less than likely. Here as in other countries, energy policy is subject to considerable vested interest influence.

Structural change in China? As with so many things, it is all in the eyes of the beholder.

Conclusions

China may at first seem to conform perfectly to the assumption that unresolved energy problems and an abundance of renewable energy resources govern energy policy. And in one sense it is true that vested interests have not to any undue extent managed to influence the political economy of Chinese renewable energy. China could easily be seen as the archetype of a country that should do, and does, well in renewables. It has major natural resources both in solar and in wind and has an insatiable hunger for more energy.

One of the reasons for the rapid implementation of renewables is the conscious targeting by the state, among other things seen in the erection of a new regulatory and institutional framework, after which growth has been formidable. But, despite the growth, there are numerous problems with the Chinese renewable energy structure, allowing for considerable vested interest abuse. The Chinese weaknesses actually bear some resemblance to the Japanese, except that in China, wind used to be the renewable industry of choice rather than solar. While not favored to the extent that solar is over wind in Japan, the expansion of wind power capacity has still dwarfed the expansion of PV. This is not because of any major institutional preference by the state, but because the structural changes required in China have been bigger with respect to solar than with wind. In Japan, solar has benefited from delivering the power directly to the households, which are already grid-connected, and at prices which the utilities have to accept. In China, with a far weaker grid network, a far poorer economy where the installation of expensive solar panels is something that is met with far more modest residential demand, and where the electricity price of solar has up until very recently been far above that of other power sources, solar PV is an industry that grew from exports rather than domestic demand, even if this is now rapidly changing. Unlike in Japan, Chinese power companies have branched out into wind rather than solar. Thus, wind power does not compete with these companies, even if the enthusiasm with which the power companies advocate wind is sometimes questionable. Also, according to the REL, the grid companies bear the cost of connecting wind to the grid. This means that there is less legal and institutional room for vested interests to block the expansion of wind, despite their often considerable reluctance to fulfill their legal obligations in terms of expanding the grid network. On the other hand, the prevalence of SOEs with lax budget restrictions makes for a very opaque institutional and regulatory environment – typically an environment in which vested interests thrive.

The eagerness with which the state has promoted renewables has made for rapid growth, but to little structural change, as total energy demand has soared to such an extent that renewable energy accounts for little more in terms of total primary energy supply today than it did 20 years ago. As an export strategy (solar) and in terms of adding to the energy supply this has been a success. But if the expansion is driven primarily by economic growth, and not coming at the expense of other sources of energy, then it remains to be seen how renewable energy will fare once the Chinese economy (inevitably) starts slowing down and budget restrictions become tougher. The fact that China has listed both solar and wind as ‘new strategic and emerging industries’, set to replace ‘old pillar industries’ such as oil and coal, is encouraging, and there certainly seems to be strong forces within the leadership that have sought to stimulate capacity within renewables with the explicit purpose of accelerating structural change in Chinese industry. So far the consequence has not been an energy transformation, and it is very likely that future Chinese renewable energy problems, to a significant extent, will be vested interest problems. Still, what it also means is that these vested interests are likely to face opposition from high up in the system.

So far, not many tough choices have had to be made, simply because most of the cracks in the institutional and regulatory framework have been papered over by growth. Thus, vested interest problems have remained maintainable, for the simple reason that in a situation where everyone prospers there is no need for vested interests to fight hard for their cause. But it is more or less inevitable that this will change. The Chinese economy can hardly keep growing at the same pace as the economy matures and as it starts bumping up against serious rigidities and inefficiencies, something that has probably been underway for some time already. While regulatory reform has been a success, there are a lot of problems still remaining, and a lot of potential for festering vested interest problems even if, for the foreseeable future, renewables will continue to expand very rapidly. The political economy of Chinese renewable energy is, therefore, characterized by two conflicting and co-existing trajectories: First, a very serious and concerted effort within renewable energy from the central government, but second, an effort that is situated within an institutional setup that is creaking, filled with tension and friction, and where there is a lot of room, leverage, and incentive to interpret (or ignore) policy directives from Beijing in whatever way that suits local vested interests, with little enforcement from the central government. This leads to the following prediction: Strong renewable growth will continue for as long as economic growth remains strong and keeps everyone happy. But if economic growth dwindles, then interest battles (primarily against influential thermal power actors) will make life a lot less charmed for renewable energy.

4

The US: Renewable Energy Doing (Reasonably) Well. Despite the State or Because of It?

Introduction

From a renewable energy policy point of view, few countries are more interesting than the United States – for better and for worse. In the US, renewable energy policy has swung more violently than in most other countries. There have been booms, busts, and protracted periods of unpredictability. In addition, the federal structure of the country leaves much of the policymaking to the states, where there are major differences in policy and in renewable energy targets. But maybe first and foremost, the US has suffered from minimalist and uncoordinated policies, punctuated by what Sovacool (2009b) describes as haphazard and inconsistent government policy, and Ernst and Young (2014b) as the crippling effects of Congressional gridlock and partisan politics.

However, let us start with the good news. The US is second behind China only on wind power capacity (66GW as of 2014). In 2012, the US installed more wind power capacity than any other country (13GW), and the high technological sophistication and low curtailment rates of its wind power means that each year US wind generates considerably more electricity than China, despite the lower installed capacity. In solar PV, at approximately 20 GW the US is significantly behind Germany, but it has one of the largest PV markets in the world, which is likely to grow rather than shrink. If we look beyond wind and solar *capacity*, to electricity *generation* (which is what actually matters), no country generates more non-hydro renewable electricity than the US. And, despite its refusal to sign the Kyoto Protocol and widespread Republican reluctance to recognize the existence of human-induced global warming, Ernst and Young (2013d, 2014a) routinely refers to the US as one of the world's two most attractive countries for renewable energy investments (with China) (*EIA*, 2014a). At the same time, as of 2013, solar and wind accounted for no more than 4.5 percent of US electricity generation (13 percent including hydropower) (*EIA*, 2014a).[1] This is far behind frontrunners such as Denmark and Germany.

As a superpower, energy security is higher on the US political agenda than in most other countries. With 5 percent of the world's population, the US consumes roughly 25 percent of global energy. Soon after World War II the US had to start importing petroleum, first from Venezuela, and then ever more from the Middle East. Today, US oil supplies are quite diversified, but combining the fact that it still depends on imports to satisfy its energy needs (even if shale gas may currently change this) and the fortunate circumstance that the US is actually quite abundant in a number of renewable energy resources, this ought to make for a political landscape in which renewable energy would be viewed favorably, as an important way of reducing energy dependence. (The US is, however, also the second largest coal producer in world, and at somewhere around 270 billion tons it hosts 25 percent of the world's recoverable reserves (Goodell, 2007).[2]) Thus, energy independence has been a topic of most American presidents since Richard Nixon.

When the 1970s oil crises struck, there was strong political support for renewables in the US. Energy policy was President Carter's first major policy initiative. Carter expected renewable energy to account for 10 percent of electricity capacity already by 1985. This proved as wildly unrealistic as forecasts by contemporary experts that by 2000, 40 percent of the global energy budget would come from renewables and that by 2025 75 percent of man's energy needs would be covered by solar energy. Technological breakthroughs were taken for granted, experts and policymakers vastly underestimating the time it would take for these breakthroughs to lead to an energy transformation. Thus, ironically, one of the reasons why the US did not follow the path of Denmark to become one of the frontrunners in renewable energy was that the belief in renewables in the US at that stage was so inflated. The consequent lack of progress led to disappointment and disenchantment with renewables (Sovacool, 2009b).

What followed was a falling out of love with renewables in conjunction with oil and coal prices dropping and resistance from the electric utilities. When President Carter's reforms expired in 1986, President Ronald Reagan dialed the renewable clock back, explicitly favoring fossil fuels, and in an act of anti-renewable symbolism, removing the solar panels that President Carter had installed on the White House roof. Unlike in Denmark, the momentum created following the oil crises vanished. Later presidents have offered similar policy ups and downs, with the inevitable consequence that for decades US renewable policy has remained unpredictable, and during President Barack Obama's administration gridlocked and subject to political partisanship, as Republicans – as well as Democratic Senators from coal-producing states – have systematically blocked change. Still, electricity generated from renewables has increased by nearly 75 percent since his election, and in 2013, President Obama presented a US Climate Action Plan, which vows to cut CO_2 from coal-fired power plants, increasing clean energy investment and innovation through an $8 billion loan guarantee program, and accelerating clean energy by permitting 10GW of renewables on public land and 3GW in military installations by 2020 (Ernst and Young, 2012b; IEA, 2014a). The vision is more ambitious and the intention more clear-cut than with any president since Carter. The problem, however, lies not in stating desirable goals, but in implementing them, as in getting bills passed by the legislature. Partisanship and gridlock have characterized an ever more toxic political environment, making this exceedingly difficult.

With probably the most sophisticated and innovative science and innovation clusters and the strongest venture capital (VC) sector in the world, in combination with a president who has made very explicit references to the importance of green economic growth and greenhouse gas emissions reductions, the US now ought to be at the forefront of renewable energy. However, US clean-energy investment in 2013 fell for the second year in a row (PEW, 2014; REN21, 2013a). PEW (2014, p.15) describes US clean-energy policy as 'in a sustained holding pattern', leading to 'dampened investor enthusiasm for the sector'. In essence, US success in renewable energy is despite itself: Government policies have been distinctly unpredictable, ranging from adequate to more or less hostile. The federal government has, however, been active in ways that are less visible and less political (hence the success), primarily with respect to technology development. But because of highly unpredictable deployment policies, this essentially means that the US has gone after the same German PV markets as China, in the belief that soon technology would improve to such an extent that PV (and wind) becomes competitive with fossil fuels on price. And from then on, market forces and the strength of US venture capital would take care of the problem. This has at best proved partially true.

Unpredictable deployment policies have something to do with the US political system, which compared to most other countries has a huge array of what George Tsebelis (2002) calls *veto players*. The checks and balances of the US system mean that initiatives can be blocked in the House of Representatives, the Senate and by the president. The Senate for all practical purposes requires a 60–40 majority, and the president has a veto that can only be overturned by a two-third majority. This leaves plenty of arenas for vested interest influence. Also, since US politicians to a major extent represent their state as much as the overall country, it is fairly easy for vested interests to lobby 'their' local Senator, so that he or she can speak on behalf of the state's particular industrial interest. Especially within the energy sector – and particularly so for coal-producing states – there has been both widespread and successful lobbying activity. It is very hard to drive anything that might have detrimental impacts on the coal industry through the legislature. Thus, in the US, the vested interest structure is very well positioned to uphold and perpetuate the current energy structure. This makes for a very uneven playing field for renewable energy. Also, while the federal government does not offer up anything along the lines of, for instance, a FIT, an RPS, or a US government target for renewable energy production or CO_2 cuts, 36 US states have announced different types of targets. Thus, often times the states are driving the process rather than the federal government. This does, however, also lead to coordination issues – or rather, issues stemming from a lack of coordination – on a scale that would seem bewildering to most countries.

Finally, this chapter ends with two major X-factors in US energy policy, namely the fracking revolution and the role played by the Department of Defense (DoD). The fracking revolution, whether it can be sustained or not, has led to US natural gas prices dropping by up to 80 percent and to oil production almost doubling. While the immediate consequence has been a reduction in coal consumption (in the process handsomely reducing US GHG emissions[3]) rather than a slowdown in renewable efforts, it does breathe new life (and sinking new investments) into the existing fossil fuel energy paradigm rather than speeding up any transformation toward a fossil-free system. The other X-factor is, however, a beneficial one. When politics is broken, where do you look for structural change? The answer is in institutions that are sheltered from politics. Thus, all branches of the US military have taken a keen interest in renewable technology, based on experiences in Afghanistan and Iraq where dependency on fossil fuels left troops exposed and vulnerable, where fuel shipments accounted for a massive part of the logistical effort, and where galloping oil prices made the war effort ever more expensive. Thus, in particular the ideal that energy-wise, bases should be self-sustainable drives very serious amounts of research and deployment of renewable equipment. The military has no time for political quarrels over global warming. What they see is increasing US energy vulnerability and the increased need for solutions to work around this, for all practical purposes, meaning renewable energy, energy efficiency measures, and microgrids. Granted, the DoD is not invulnerable against political attacks, but compared to other branches of government, it has been allowed to run its programs fairly unhindered by politicians and vested interests. It could well be that with politics gridlocked the US military constitutes the most important long-term government stimulus for US renewable energy.

Wind power

The US has the second largest installed wind power capacity in the world, behind China. Growth has not been as spectacular as in China – the US had the world's largest installed capacity as late as 2009 (surpassing previous leader Germany in 2008), but since then, China has stormed ahead and as of 2014 had 115GW of installed capacity, against the US with 66GW. However, US wind turbines are more sophisticated, and China has far more off-grid capacity and curtailment problems than the US. Thus, the US in 2013 generated 167TWh of electricity from its installed capacity, compared to just 138TWh in China. For three years in a row (2012–14), the US has now generated more than 20 percent more electricity from wind than China, despite the Chinese installed capacity in 2014 growing to be a full 75 percent larger than that of the US (AWEA, 2015a, 2015b; *Cleantechnica*, 2015; GWEC, 2015). In 2012, 42 percent of installed power capacity came from wind power – the first time that wind power had been the biggest source of new US electricity generating capacity – and in what was a record-breaking year, in 2012 the US installed more capacity than even China. Colorado on one day in May 2013 produced more than 60 percent of its electricity by wind. The US is also venturing into the offshore market, with the Obama administration auctioning off 5.5GW of offshore capacity, which suggests new avenues for future wind power growth. And after being accustomed to Danish company Vestas being the permanent global wind turbine market leader, in 2012 US giant General Electric (GE) took the number one spot, with a global market share of 15.5 percent. While China has built impressive wind power companies, such as Sinovel and Goldwind, it is also the case that these companies hardly export, among other things, because the Western competition is still notably ahead on technological sophistication and reliability (*EIA*, 2014a; GWEC, 2014; PEW, 2014; REN21, 2013).

Thus, there is little doubt that US wind power has a lot going for it. There is, however, little reason for euphoria. 2012 was an exceptional year. Granted, in 2013 which was a far slower year, renewable energy still accounted for 37 percent of new electricity capacity – not at all unimpressive – but wind was down to only 8 percent, and instead natural gas – driven by the US fracking revolution – accounted for a full 50 percent. Also, US renewable investments fell for the second year running (although still the second largest in the world). Wind power installation figures collapsed, from a record 13GW in 2012 to a little over 1GW in 2013 – the lowest figure since 2004. For this reason, GE's global market leadership was short-lived, as it slumped to a 6.6 percent market share in 2013. The year 2014 was better, with almost 5GW of installations, but the general trend is one of fundamental unpredictability (AWEA, 2013a, 2014; GWEC, 2015; PEW, 2014; REN21, 2014; *SI*, 2014).

The main reason for these dramatic fluctuations is the production tax credit (PTC). As one of the main tools in the federal renewable energy toolbox, it was instituted by President George H.W. Bush with the 1992 Energy Policy Act, set at 1.5¢/kWh and then raised to 2.3¢/kWh (for the first ten years of operation). However, it has been allowed to expire on a number of occasions, and every time the result has been a dramatic drop-off in installations, which can be seen in Figure 4.1. Thus, a major part of the 13GW record capacity installed in 2012 can be credited to the fact that the PTC was expected to expire at the end of the year. Investors scrambled to connect their wind turbines before the end of 2012, so as to benefit from the PTC. Thus, the flipside to the 2012 13GW boom was a 2013 1GW bust – a drop of 92 percent, followed by layoffs, facility closures, and firms vacating the wind power industry, as has been the case on previous PTC expiries. The American Wind Energy Association (AWEA) claims job losses of 10,000, with possibly 37,000 more to follow (AWEA, 2013a). REN21 (2013, 2014) reports a decrease in US wind power jobs during 2012–13 from 81,000 to 51,000. Vestas has cut its share of US jobs by a fifth. Thus, these are substantial and not particularly healthy swings. The PTC was also allowed to expire in 1999, 2001, and 2003 as well as a near lapse in 2008. This led to wind energy installations dropping by 82 percent in 2000, 76 percent in 2002, and 79 percent in 2004 (IEA, 2014b).[4] In contrast, with the more stable policy framework between 2005 and 2009, installations quadrupled from less than 2.5GW a year to almost 10GW. During the latest shenanigans surrounding the

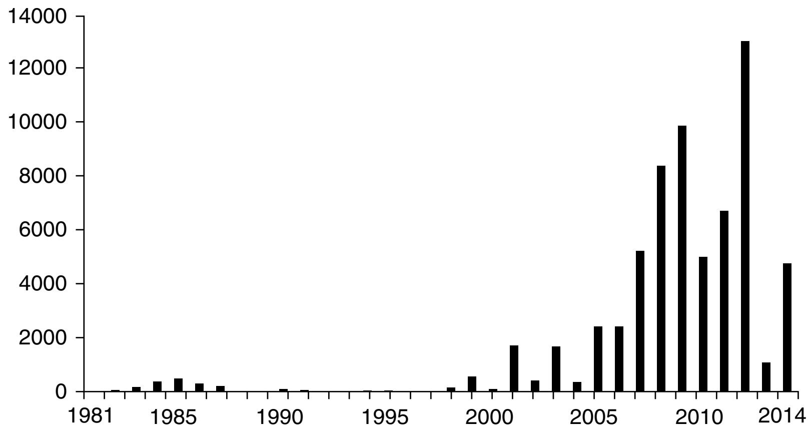

Figure 4.1 Annual US wind power installations, 1981–2014 (MW)
Sources: Calculated from IEA (2014b) figures; GWEC (2015).

PTC, it was reinstated on December 31, 2012, but then again left to expire on the same day in 2013. The reinstatement came too late to prevent the 2013 bust, leaving the future in doubt. However, in the latest PTC, projects only have to be *under construction* (rather than operational) by January 1, 2014 in order to qualify for the PTC.[5] This simple change of language may drive future growth, although in May 2014, there was another twist as attempts at extending the PTC for two more years were blocked in the Senate, once again reducing the predictability. At the time of writing there is 12GW of wind power under construction, almost 11GW of which was initiated before December 31, 2013, thus qualifying for the PTC (AWEA, 2013a, 2014; Ernst and Young, 2012b; GWEC, 2011, 2013, 2014; PEW, 2014; *Power*, 2014a; Skodvin, 2010; Sovacool, 2009b; *Windpower Monthly*, 2014; WWEA, 2013).

US wind, however, goes further back than the PTC. As in Denmark, Japan, and a host of other countries, the 1973 oil crisis was a prime mover, as the US initiated a federal wind energy program that same year, with the first experimental turbine operative by 1975. In 1982, the so-called California Wind Rush became the first global wind power boom.[6] As mentioned in the Denmark chapter, the wind rush created the first major expansion opportunity for Danish wind power firms, benefiting enormously from the California rush. In 1985, almost 500MW was installed (see Figure 4.1), a figure not surpassed until 1999. In 1988, California held 1540 of the world's total 1800MW of wind power capacity (IEA, 1985, 1989). But in 1986 the Federal Energy Investment Tax Credit (ITC) introduced by President Carter expired (AWEA, 2013b), and between 1988 and 1997 only negligible amounts were installed, the US losing its lead to Europe. It picked up again in the late 1990s with the Great Texas Wind Rush, supported by then Governor George W. Bush who told the chairman of the Texas Public Utility Commission, Pat Wood, that 'we like wind. Go get smart on it' (Galbraith and Price, 2013, p.121). Before leaving the governor's mansion, he introduced a ten-year Texas target of 2GW of installations and signed an RPS. Thus, Texas raced ahead of the rest of the country, and now has a total of 13GW of installed capacity. Moreover, Texas, also prioritized the electric grid and built the necessary transmission lines to bring renewable electricity to the consumer, something which has been a problem in many other states (*Bloomberg*, 2015c; Galbraith and Price, 2013; *Greentechmedia*, 2010; *INYT*, 2010).

More so than elsewhere, US wind power has been characterized by booms and busts, starts and stops, and on different states waxing and waning at different times rather than by any policy predictability at the federal level. The US was a pioneer with the California Wind Rush, then lost its lead, then Texas led the way within the US, while expirations to the PTC have led to the almost complete halt to all installations. The US has one of the biggest wind power players in GE, whereas Kenetech – once the world's largest wind turbine manufacturer – went bankrupt during the ten-year installation hiatus.[7] Even today, with some of the biggest and technologically most sophisticated wind turbine players in the world, with the world's second largest installed capacity and the largest wind power electricity generation, the future is uncertain. With 12GW of projects in the pipeline, the immediate future (up until 2016) is reasonably bright, and the Obama administration is certainly looking to provide more predictability and stable framework conditions. Still, even if the industry seems cautiously optimistic, compared to, for instance, China, the future for wind power seems far less certain, and far more subject to abrupt policy swings.

Solar power

The US has also seen considerable growth within solar PV. With a total capacity of 20GW, the US is considerably behind Germany's 38GW. It has also lately been surpassed by Japan and China. But at almost 5GW of installations in 2013 and an estimated 7.5GW in 2014, the US market is now the world's third largest, behind only Japan and China. As with most countries, the US has far less solar than wind power. However, since 2008, investments in solar power have been larger than for wind, and in 2013 no other renewable source of energy accounted for more of the new electricity, with 22 percent of the newly installed capacity that year. As mentioned above, 2013 was a bad year for wind, and thus a somewhat unfair year for comparing wind and solar. However, it is worth noting that the figure of 22 percent was up from only 6 percent the year before, and that, despite the end of the PTC, installation of solar power has kept increasing year on year for the past 15 years, and even accelerating. The US in 2012 phased in the largest solar facility in the world, a 250MW plant in Arizona. Thus, PV has avoided the booms and busts of wind and has experienced steady growth – 2014 being the best year on record so far.[8] EPIA (2013) predicts that the size of the US market will reach 10GW before the end of the decade. Still, despite this recent success, solar is a minor player. Wind power contributes a little over 4 percent to US electricity generation (still pretty low compared to Denmark and Germany), whereas solar only accounts for a quarter of a percent (*EIA*, 2014a; EPIA, 2013, 2014b; REN21, 2013; *SEIA*, 2014; SI, 2014).

California, which in 2013 installed more than 2.5GW, hosts nearly half the overall US capacity. A sunny climate is obviously part of the reason, but the Californian solar industry has also met with supportive policies at the state level, with Governor Jerry Brown, for instance, setting a goal of 12GW (including wind power) by 2020 (*Los Angeles Times*, 2011; *Power*, 2014b; *SEIA*, 2014).

Like much of the global solar industry, the US industry has had a rough few years. US PV production, which was the largest in the world in the 1990s, now accounts for only a little more than 2.5 percent of the world market. The US still has two of the largest solar companies in the world, First Solar and SunPower. First Solar has previously held both the largest and the second largest market share in PV modules, but has now had to close down production lines and has dropped out of the residential market in order to focus on utility-scale plants. In 2013, it held the world's seventh largest market share, whereas SunPower had dropped out of the top ten. Over the past few years, as many as 24 US solar manufacturers have left the business. The most highly profiled was undoubtedly Solyndra, held up by the Obama administration as an example of the new, bright future of US solar and renewable industry and of green economic growth, before spectacularly bankrupting (Mazzucato, 2013; REN21, 2013, 2014).

Part of the US response to Chinese competition has been to accuse China of dumping. Mazzucato (2013) argues that US solar power has benefited as much from state-sponsored research funding as most other countries, and thus may not be overly unfairly disadvantaged compared to the Chinese industry. And Lewis (2013) makes the point that the almost exclusive focus on PV production, in the US as well as in international statistics, obscures the picture. In fact, the US has a positive trade balance with China in solar, as China primarily populates the lowest-value segments in the solar PV supply chain. Thus, as late as 2010, the US ran a solar export surplus with China, with polysilicon and capital equipment for PV manufacturing being the two biggest exports. In any case, regardless of the actual state of the US solar industry, the US has slapped a very heavy punitive tariff on Chinese PV manufacturers, ranging from 31 to 250 percent for some companies, and China has in return imposed import duties on US polysilicon companies (*Economist*, 2012a; Ernst and Young, 2013c, 2013d, 2014a).

Vested interests

Before delving too deeply into the US vested interest structure, it is worth noting that US renewable energy has been subject to a number of historical swings simply because of political swings, and more so than in most other countries. Thus, in the Denmark chapter (Chapter 6) we find an institutional and political setup that was geared toward supporting wind power, and in Norway (Chapter 7) a setup geared toward the needs of petroleum. It is far harder to find similar overarching themes in the US. Instead, with some exceptions many of the swings in the fortunes of renewable energy seem not particularly systemic.

Therefore, let us start by taking a brief look at some of the previous presidential periods. These are characterized by major swings, by a lack of predictability, of booms and busts, a lack of institutionalization of renewable energy policy, and by constant vulnerability to political shifts – and from lobbying activity from fossil fuel actors. Here, the federal and decentralized structure of the US makes overarching and coordinated renewable energy policies difficult to carry out. A number of US states have very influential coal and petroleum interests, and Senators and Congressmen representing these states often serve more as spokesmen for their own states than as elected representatives for the nation as a whole. Thus, lobbyists in Washington DC will normally be able to find elected representatives who are willing to listen and fight on their behalf. It is a system that invites vested interest battles and is typically something that favors the established industries and not the newcomers.

However, going back to President Carter (1976–80), the enduring belief was that the US would rid itself of its energy dependency by investing in renewable energy, and that the sky was the limit. Energy policy was his first major policy initiative, and of the five laws that were passed, the 1978 Public Utility Regulatory Policies Act (PURPA) was the most important (although possibly by accident rather than design), with provisions that stimulated research on environmentally preferable technologies, and establishing the first production tax credit for renewable energy systems (Sovacool, 2008).

The rapid progress that was anticipated simply did not materialize. While there was an assumption that from the 1970s oil crises onwards, petroleum prices would just keep on increasing, in the 1980s instead they dropped. Non-renewable technology costs kept dropping faster than renewable costs, thus despite both wind and solar becoming cheaper and more efficient, coal was getting *even* cheaper. This led to disenchantment and disillusionment with renewable energy, and came on top of stubborn resistance against renewables from electric utility companies and a greater overall emphasis in the energy policy on cost effectiveness. Renewable energy bankruptcies and broken down wind and solar farms stemming from hope (and hype) turned the American mind against renewables and made it harder for renewable energy to regain the lost ground once the technologies were starting to catch up with the initial promise.

President Reagan (1980–88) pretty much terminated the renewable illusions of the Carter era. Federal funding for renewables, which had peaked in 1980, dropped by nearly 90 percent, driving people out of renewable energy and by 1982–83, complete political discouragement had made almost everyone leave the industry. Thus, as Denmark became one of the most consistent supporters of renewable energy, the US retreated. The only energy transition of the 1980s was one back to fossil fuels. Renewable projects were abandoned as incentives were removed and policies shifted, whereas subsidies and incentives for conventional power generation remained (and still remain) stable. Maybe the importance of government support can be seen most clearly in what happened upon its withdrawal, namely the crash of the renewable sector in the US and the subsequent shift in momentum from the US to Europe. Up until then, the California Wind Rush constituted the most important wind power market in the world, to the extent that Denmark based a whole wind industry around it (AWEA, 2013b; Mazzucato, 2013; Sovacool, 2008, 2009b; Vestergaard et al., 2004).

The George H.W. Bush administration (1988–92) was more of a return to form for renewable energy. Bush, with the 1992 Energy Policy Act, was for instance the one who instituted the production tax credit for renewable technologies, which has been among the most important parts of the US renewable energy incentive system ever since – although maybe most easily noticed during those years when the PTC was allowed to lapse, causing major busts to renewable energy investment. The lapses and near-lapses of the PTC and the difficulty with which it has often been renewed are very indicative of the swings and arbitrariness of support for renewables in the US, and the lack of institutionalization of a support system. The Bush PTC expired in 1999. Since then, it has had to be reinstated, often on an annual basis, and thus often subject to a Congressional tug-of-war, leading to expiries in 1999, 2001, and 2003. Thus, as described earlier, the US has been inflicting booms and busts upon itself with alarming regularity, providing the industry with precious little predictability. Beyond these three lapses, there have also been near-lapses, giving us insights into the political processes that engulf renewable energy policy. In 2008, only at the 11th hour, after numerous failed attempts, even in a US Congress where the PTC was considered fairly uncontroversial, did a PTC go through. At first, it (and a federal RPS) was part of a general energy bill, but one that was only passed *after* the PTC (and the RPS) had been taken out of the bill. The PTC was then included in an economic stimulus package, which was also defeated. Combined with a housing bill, the PTC then passed the Senate. However, the increased expenditures were not offset in the budget, and the proposed budgetary offsets included repeal of oil industry tax breaks and subsidy investments, and they would have been blocked either by a Senate minority or vetoed by the president. After yet another set of failures, the PTC extensions were then included in a broader bill extending tax credits to a number of groups and activities. This bill was also blocked by what seemed like a permanent Republican minority refusing to allow renewable energy legislation that did not also simultaneously remove the moratoria on drilling off the continental shelf and in Alaska. The PTC was finally passed in September 2008 (almost a year and a half after the first attempt), but then not as part of any 'regular' bill, but as part of a 'Wall Street bail-out package' to counter the financial crisis (Skodvin, 2010; Sovacool, 2009b). In 2012, the PTC once again was allowed to expire, then reinstated for 2013, but expiring also at the end of that year. As mentioned, the inevitable consequence was that the record-breaking boom-year of 2012 gave way to the spectacular bust and crisis year of 2013 and a drop of 92 percent in installations. Most recently, in May 2014, party politics again blocked the extension of the PTC, preserving the limbo of US wind. In his budget for 2016, President Obama has suggested to make the PTC permanent, but it is highly doubtful if the Republican-controlled Senate and House will sanction this (AWEA, 2013, 2014; *Greentechmedia*, 2015; GWEC, 2013; PEW, 2014; *Power*, 2014a; *UCSUSA*, 2014; *Windpower Monthly*, 2014; WWEA, 2013).

However, if the PTC has been a lifeline for renewable energy, it is also conspicuous how renewables populate an energy political landscape dominated by some very powerful fossil fuel giants. During most administrations, the relationship between fossil fuel interests and the state has been close, but during the presidency of George W. Bush (2000–08) it became almost incestuous. Now, energy policy shifted very explicitly as to openly cater to these groups, very much away from any attempt at reducing CO_2 emissions. Even the briefest glance at US resource endowments reveals that coal is important to the US energy structure. The US has the world's largest coal reserves, is the second largest producer (after China), and could at current rates be self-sufficient in coal for 250 years. Thirty-seven percent of US electricity stems from coal, and it accounts for 33 percent of energy-related US CO_2 emissions (Caldecott, 2013; Geri and McNabb, 2011).[9]

In 2000, the coal industry saw the potential election of Al Gore as a major threat; its preferred president was very much George W. Bush. The world's largest private coal company, Peabody Energy, donated $846,000 during the 2000 election campaign,[10] of which 98 percent went to Republicans, and between 2001 and 2004 donated more than $2 million in federal campaign contributions, practically all of it to Republican candidates. It is widely believed that Gore lost West Virginia (enough to lose him the presidency) because he was perceived to be anti-coal (Shaffer, 2009). In *Big Coal*, Goodell (2007) goes further, stating outright that contributions from the coal industry was what helped Bush win a number of crucial coal-producing states, including West Virginia. Whether this was the case or not, the coal industry certainly backed Bush, and following the election received its reward as regulatory agencies were staffed with former coal industry executives and lobbyists, resulting in the crafting of a new and unashamedly pro-coal energy policy, very much in contrast to the new president's claims during his presidential campaign that the US needed to curb its CO_2 emissions. Goodell (2007) paints a picture of a president who actively and eagerly repaid the favors from the coal industry, which was never in doubt that

Bush was 'their man'. The head of the National Mining Association, Jack Gerard, openly admitted that 'the 2000 election [was] a big one for us' (Goodell, 2007, p.184). Thus, the Bush era led to 150 new coal plants, $130 billion in investments, and the re-opening of old mines. Instead of subsidizing renewable energy, the 2005 Energy Policy Act contained a $5 billion subsidy for the coal industry, of which clean coal technology received $2 billion (Bang, 2010; Goodell, 2007, p.215).

On the campaign trail Bush had advocated a mandatory cap on CO_2 emissions, and as governor of Texas he strongly backed wind power only a year before being elected president. But less than two months after the election, President Bush withdrew US support for the Kyoto Protocol, and throughout his presidency environmental issues took a back seat. Environmental laws and regulations were weakened and both he and Vice President Dick Cheney on numerous occasions expressed doubts about global warming, possibly even suppressing scientific evidence. Any regulation of CO_2 was actively prevented, and it was not until 2009 under a new leader and a new US president that the EPA could officially state that greenhouse gases are actually dangerous (Goodell, 2007; Harris, 2009; *Time*, 2009).

In his 2006 State of the Union address, President Bush proclaimed that the US is 'addicted to oil', and called for reducing oil imports from the Middle East by 75 percent by 2025 (Coll, 2012; Shaffer, 2009). The US needed to be more energy independent, and the best way in which to achieve this was through clean-energy research and ethanol. However, to the extent that the Bush administration was looking for structural change and a Schumpeterian energy moment, it was hydrogen and ethanol and not wind and solar that were the preferred choices, playing into the hands of already existing vested interests. True, the 2005 Energy Policy Act also promoted renewable energy – 2005–09 saw wind power installations soar (from 9GW to 35GW) – but to the extent that it provided a shift in energy policy, it did so in the direction of oil, gas, nuclear, and coal, as the Act put the emphasis on extracting more oil and gas domestically – on the continental shelf and from oil shale and tar sands – as well as including enormous subsidies for nuclear (Bang, 2010; Geri and McNabb, 2011; GWEC, 2014; Sovacool, 2008).[11]

Hydrogen would allow the US to preserve much more of its already existing energy infrastructure. Thus, if successful in the long run, an obvious benefit of hydrogen would be that it would require little structural change and thus potentially be relatively inexpensive. To the oil industry, ethanol, however, made little sense. ExxonMobil Chairman Lee Raymond was openly hostile toward the Congress' giant 51¢/gallon subsidy for ethanol and the 2005 Energy Policy Act that mandated a rising annual minimum use of ethanol, as it would be 50 percent more expensive than regular gasoline, denouncing it as politically driven. From a climate point of view, US corn-based ethanol is one of the least efficient ways of producing ethanol, at best reducing GHG emissions by 13 percent, and possibly even increasing them once land-use change is taken into account. Nevertheless, with President Bush's declared goal of ethanol to replace 20 percent of US gasoline consumption in 20 years, and the target of 36 billion gallons (roughly 20 percent of total transportation fuel) of annual biofuel use by 2022, there has been a vast expansion of ethanol in the US, tripling in production during 2002–08 from 2.8 to 9 billion gallons and taking up an increasing proportion of the US corn crop, up from 6 percent in 2000 to 24 percent in 2008. The reason why the US opted for ethanol, with all its disadvantages and relatively few advantages, instead of renewable energy, can only be explained with vested interests, although *not* fossil fuel-based vested interests. Rather, farming interests[12] have pushed hard for ethanol, and Congress members from corn-growing states have advocated ethanol on their behalf. The corn-growing states all have fairly small populations, but each state has two Senators, irrespective of the state's population, and since there are quite a number of corn-growing states, they have been able to speak with a disproportionately strong voice in the Senate (Bang, 2010; Coll, 2012; Geri and McNabb, 2011; Shaffer, 2009).[13]

This takes us to what may easily be the core problem of US energy policymaking, namely the amount of veto players, or the number of actors who are able to block legislation. Thus, the point here is not to put sole blame for the lack of renewable progress on the Bush administration. The president is naturally the most high-profiled US political actor, and he does to a major extent set the political agenda, but the US system is one of checks and balances, requiring a proposal to have the approval of the House of Representatives, the Senate, and the president. This makes it very hard to push through more than incremental changes to energy policy, comparatively easy for vested interests to be successful in their lobbying and ultimately very hard to change the status quo – even more so as in the Senate for most major legislation a 60–40 majority is necessary in order to prevent the opposition from filibustering.

And lobbying certainly exists. There is little doubt that Washington DC has become more prone to vested interest activity. Since 1955, the number of special interest associations in Washington DC has grown from less than 5000 to more than 20,000 and the number of lobbyists registered with the Senate from 3000 to more than 13,000. The number of lawyers in Washington DC has grown from 12,000 to 76,000 (Fukuyama, 2014; Geri and McNabb, 2011). More specifically, Sovacool (2008, p.230) reports Greenpeace figures estimating that US oil, natural gas, and coal companies spend $31 million a year on lobbying and campaign contributions. However, during important election years this number can catapult. During the 2004 presidential campaign, oil and gas companies contributed $255 million, with electric utilities chipping in an additional $20 million. Between 2003 and 2006, fossil fuel lobbyists spent $58 million on state-level campaigns, compared to a total of $500,000 from renewable energy lobbyists. The coal industry has also been skilful at setting up 'grass-roots' organizations that have turned out to be nothing more than well-funded fronts for pro-coal lobbying (Sovacool, 2008).[14] There is little doubt where the financial power lies.

That the coal lobby in conjunction with representatives from coal-producing states has major sway over US energy policy is no secret (among others from the electricity sector, which consumes 90 percent of the coal that is used in the US) (Bang, 2010; Shaffer, 2009). With the 2008 PTC, there was strong evidence of interest groups lobbying for coal against a PTC for renewable energy. The high representation of Senators from major and minor coal-producing states suggests that the PTC was perceived as 'part of a transformation toward a less fossil-based economy' (Skodvin, 2010, p.4221). And in an as pro-renewable administration as the Obama administration, Congress representatives – Democrats as well as Republicans – from districts with higher carbon emissions and greater campaign contributions from the mining industry, consistently voted against The American Clean Energy and Security Act of 2009 (H.R.2454). Resistance was more stubborn among Republicans, but what made change particularly hard was the opposition among Democrats from high-carbon states, going against their own president in the pursuit of the economic interests of their home states (Zusman et al., 2012). The pattern of individual politicians from high-carbon states preventing policy outcomes that go against coal (and petroleum) is obvious. Post-9/11, energy security has frequently been used as a rationale. Thus, in 2007 legislation to promote the use of coal-to-liquids (CTL) fuel was explicitly introduced with references to energy security (and to the benefit of the domestic coal industry).[15] Thus, for a number of US politicians, energy security has come to mean something that stands in opposition to, and overrides, climate change, and very often implicitly renewable energy (Bang, 2010). Efforts to repeal energy subsidies have faced similar problems. In 2007, the House of Representatives sought to repeal $22 billion of subsidies for oil and gas as part of the

Energy Independence and Security Act. It passed by 235 to 181 votes, but was thrown out by the Senate – 59 voted in favor and 40 against, but because of Republican filibustering 60 votes were required. In any case, if it had passed in the Senate, President Bush would have vetoed it. The same fate befell a provision to include a Renewable Electricity Standard (Sovacool, 2008).

However, while the checks and balances of the US systems often make it difficult to implement major change, there are ways to bypass this. The inability of President Obama to pass major environmental and energy-related legislature in the House and Senate made him go to the EPA instead. The 1970 Clean Air Act, signed into law by President Nixon, requires the EPA to regulate pollution that threatens public health and welfare and was affirmed by the Supreme Court in 2007. In 2009, the EPA included CO_2 among the gases that it regulates. Thus, sidestepping elected politicians, as part of President Obama's Climate Action Plan, the EPA in June 2014 proposed the Clean Power Plan, which aims to cut carbon emissions from the power sector (in particular coal-fired plants) by 30 percent (base year 2005).[16] By 2016, the states need to come up with plans by which to cut carbon emissions by an amount that the EPA has specified (differing from state to state), and coal is by far the biggest loser in this scheme.[17] (It is, however, not yet equally obvious if the main winner is renewable energy or natural gas.) By 2020, 60GW of coal-fired capacity should easily be phased out. There most likely will be legal challenges against the Clean Power Plan from coal interests, but the combination of an EPA and a president who both desire stricter regulations on coal still makes it conceivable to sidestep the vested interest structure by making this into a part of a technocratic health and welfare regulation implementation scheme (*Economist*, 2014d; *EPA*, 2014b; *Newrepublic*, 2014).

Another ray of hope for renewables is the fact that despite being a state better known for petroleum than environmentalism, the current US frontrunner on wind is Texas. This is a strongly Republican state, which under a Republican governor with major oil credentials (George W. Bush) initiated the greatest growth in wind power so far seen in the US. The petroleum industry initially resisted, most notably by trying to sway county officials not to grant wind power key abatements on property taxes, but wind power won through, which is an example of renewables growing in the face of powerful vested interests (albeit somewhat waning interests, in an economy that was at the time searching for new business opportunities). It could be argued that the political tide has since changed, and that the grand bargains that enabled this took place pre-Tea Party, and that Texan wind power has flourished because of policies that the Tea Party would normally oppose. However, it could also be argued that since 75 percent of US wind power capacity and 67 percent of the wind power manufacturing facilities are in Republican districts, pro-renewable policies should be embraced by Republicans. This has been argued by Republican think tank and lobbying group Red State Renewable Alliance. And while this may seem far-fetched in today's toxic political climate, it is worth remembering that there are lobbying efforts on behalf of renewables as well, and that both Republicans and Democrats might be able to find common ground as to why they would advocate the expansion of renewable energy. Influential business groups do lobby for a comprehensive national energy strategy, with a permanent, but gradually lowered, PTC (a little like FIT degressions in European countries) (Ernst and Young, 2012b, 2013b; Galbraith and Price, 2013; *Oilprice*, 2012).

However, the Texas example is also conspicuous for being about state politics, and not federal. This provides us with a nice segue to the following subchapter. The US is a federation. And for all practical purposes energy policy is run as much by the states as by the federal government. This also means that the states serve both as renewable drivers and as further arenas for vested interest in-fighting. In both China and Japan the electric utilities have been stumbling blocks against change. This is also the case in the US, which is another reason for the absence of major structural change. To explore this, we have to look at state rather than federal policymaking, as the utilities are organized by state or region. Among the states we also find RPS schemes, a few FITs, and a cap-and-trade system, adding further to the complexity of the political economy of US renewable energy.

Federal vs. State

The argument could easily be made that the US has no *one* renewable policy, but many. Most of the other countries discussed in this book have easily identifiable targets for installation of different types of renewable technology and GHG emissions, and they have used a combination of FITs and RPS systems to phase ever more renewable energy into the grid. The US does not have any of this.

What the US does have is 50 states (plus Washington DC) that are all free to impose environmental and renewable energy targets. Hence, US energy markets are regulated not at the national level, but at the state level, which is also where the utility companies operate. Thus, each state is a separate energy market (Burns and Kang, 2010). At the time of writing, 36 individual states and the District of Columbia have introduced an RPS. The targets vary considerably from state to state. Iowa (1985) and Minnesota (1994) were first, and California, Colorado, and New York have been among the other frontrunners. California, which introduced an RPS in 2002, has set a standard of 33 percent of retail sales of electric utilities to come from renewable energy by 2020, Colorado mandates 30 percent from investor-owned utilities by 2020, whereas New York has set a target of 29 percent by 2015. Other states have installation targets, such as Texas, which targets 10GW of new installations by 2025. On average, states strive to achieve around 20 percent of total power consumed from renewable energy by 2020. California and Hawaii have established FITs, whereas five more states have programs somewhat resembling FITs. In addition, California in 2013 set up an emissions-trading scheme, a cap-and-trade program, second in size to the EU system only. It seeks to reduce GHG emissions to 1990 levels by 2020, and will by 2015 encompass 85 percent of the state's emissions, including the often omitted transportation sector (Burns and Kang, 2010; *C2ES*, 2014; *California Carbon Dashboard*, 2014; *DSIRE*, 2014; *EIA*, 2013a, 2013b; *Forbes*, 2014; Sovacool, 2009b; *theenergycollective*, 2013d).

State policies are, however, not uniform. Thus, 99.5 percent of all solar PV installations are located in only eight states, in particular California, which saw more than 70 percent of the PV installations in 2013. Wind power is a little more evenly distributed, but Texas holds about 20 percent of the overall US capacity of 66GW (AWEA, 2014; *EPA*, 2014a; *Solar Industry*, 2014). A difference between a 20 percent share by 2020 and 25 percent by 2030 between two hypothetical states may seem trivial, but the reality is far more complex. 'If America's interstate highway system were structured like its renewable energy market, drivers would be forced to change engines, tire pressure, and fuel mixture every time they crossed state lines' (Sovacool, 2008, p.159). Moreover,

> In Maine, fuel cells and high efficiency cogeneration units count as "renewables", while the standard in Pennsylvania includes coal gasification and fossil-fueled DG technologies. Iowa, Minnesota, and Texas set their purchase requirements based on installed capacity, whereas other states set them relative to electricity sales. Minnesota and Iowa have voluntary standards with no penalties, whereas Massachusetts, Connecticut, Rhode Island, and Pennsylvania all levy different noncompliance fees. The result is a renewable energy market that deters investment, complicates compliance, discourages interstate cooperation, and encourages tedious and expensive litigation. (Sovacool, 2008, p.159)

This is complicated further by the fact that of all the renewable technologies, PV is the most expensive. Thus, for an RPS to include any PV, technology-specific 'set-asides' (a provision whereby the utility is obligated to set a certain percentage of its RPS aside for specific renewables) have been added on to the RPS systems in 16 states, adding to the difference between them. Nine states have tradable solar credit markets (Burns and Kang, 2010). Sovacool (2008) goes on to note that the problem is accentuated by the fact that many utilities are multistate. Thus, American Electric Power has more than five million customers and has to deal with competing statutes in 11 states. While in some respects, the lack of federal renewable energy initiatives is compensated for by states forcing the issue,[18] these initiatives do not make up for the lack of a federal effort. Coordination problems and transaction costs are high and constitute clear impediments on the development of renewable energy.

It also means that since it is the states that have established RPS systems, they are as relevant an arena for vested interest battles as the federal government. This applies in particular to the electric utilities. Massachusetts has just become the first US state to mandate that the state's utility companies modernize their grids (as in implementing a ten-year grid modernization plan). In the US, by 2035, a massive $2.1 trillion may have to be invested in power sector infrastructure. These are expenses that the utilities cannot easily bear. Having to upgrade the grid among other things because of the inflow of renewable energy will undoubtedly cause vested interest battles over the future of US energy policy (*Clean Edge*, 2014a; *Power*, 2014f).

In general, most US utilities have been skeptical, or downright hostile toward renewables, mirroring the resistance seen in other countries with the argument that renewable energy is incompatible with existing systems of centralized power generation. In the investor-owned utilities, renewable energy accounts for only 1.4 percent of the electricity portfolio. Instead, fossil-fueled electricity has been considered the only realistic option. While it would require an entire book by itself to go through the policies and politics of 50 different states, Colorado seems instructive. Here, no policy incentives existed before 2004 and coal accounted for more than 85 percent of the electricity supply. Wind was not perceived as a credible option. Environmental lobbying in the mid-1990s failed outright, but in 2000 lobbying resulted in the utility introducing a green pricing program that gave consumers the option of buying renewable electricity at premium prices. Three years of lobbying (2002–04) in the Colorado legislature for an RPS, however, failed, mainly because of opposition from opponents of renewables. Here, as elsewhere, the next step was to bypass the legislature by introducing a ballot (2004), whereby Colorado residents could vote on whether or not to introduce an RPS. This was achieved through environmental lobbying in cooperation with pro-renewable politicians, arguing that this would not only be a good idea in a state that is over-reliant on coal, but also be a good opportunity for rural development, as well as allaying fears that wind would be expensive and volatile (Doblinger and Soppe, 2013). An RPS was eventually introduced. More importantly, the process says something about the prospects for change: First, renewables were fought by vested interests. Second, environmental lobbying was blocked in the legislature by established vested interests and partisan politics. And third, the most effective way of still getting legislation passed, was to sidestep politics and use political channels that were less vulnerable to vested interest influence. This was the case in Colorado, and it has been the case on a multitude of other occasions.

Subsidies

Energy subsidies are another measure of vested interest bias. A 2006 analysis showed that out of energy subsidies of roughly $74 billion, 66 percent went to fossil fuels and 8 percent to renewables.[19] Between 2002 and 2007, 75 percent of all energy-related tax credits went to fossil fuels and only 15 percent to clean power systems. During the same period, of all Department of Energy (DoE) related R&D subsidies, nuclear received 54 percent. Between 1947 and 2000, cumulative subsidies for nuclear power were more than 100 times larger than those for wind.[20] And for all practical purposes these figures most likely *under*estimate the real amount awarded to fossil fuels and nuclear quite substantially. Between 1978 and 1995, federal subsidies for clean coal amounted to $12 billion, or two-and-a-half times that of subsidies for wind. And of the OECD countries, in 2001, the US accounted for 70 percent of all coal subsidies. This is not a structure that is particularly conducive to structural change. Instead, it keeps funneling more resources into the already existing and strongest energy actors in the system.

President Obama in 2008 came to power with a goal of reducing US energy dependence through renewables rather than ethanol,[21] hydrogen, and clean coal, and with an aim of creating green growth by intensifying research in renewable technologies and fostering renewable industries as the growth industries of the future. Thus, here was at least someone who came to power with a rhetoric of structural change, and a rhetoric of industrial regeneration through renewable energy industry. During the presidential campaign he promised to create five million ‘green collar jobs' and to introduce cap-and-trade legislation that would reduce GHG emissions by 80 percent below 1990 levels by 2050 (DiPeso, 2009).

Indeed, as part of the economic stimulus packages that were meant to get the economy going again, more money has been funneled into renewable energy and energy efficiency than ever before. Thus, here was the idea of using an economic crisis as a lever for change, somewhat along the lines of how previous economic shocks have led to structural economic change in the past.

However, despite this, President Obama has found it hard to reform energy policy. As seen above, the PTC is still frequently held hostage by a gridlocked Senate, and the Republicans as well as Democrats from coal states have joined forces to block bills that have been perceived as threatening to coal. True, the Obama administration has seen coal's contribution to electricity production drop from a seemingly steady 50 percent during the previous decade to 37 percent in 2012, which is a striking turnaround in the fortunes of coal, and a potential sign of unfolding structural change. Yet, the main reason for this is the US shale-gas revolution (more about which later). And while this undoubtedly represents a weakening of the US coal industry, and also reduces GHG emissions – which have dropped to their lowest level since 1995 (*theenergycollective*, 2013d) – it is a shift in power from one fossil fuel based energy source to another, rather than one toward sustainable fuels. Also, while it is a technologically based shift (fracking technology), coal has lost competitiveness not because of government initiatives, but because of market forces. While there is nothing wrong about market forces, the point here is that this major swing in coal's fortunes is not one that the present administration can take credit for. That said the Obama administration is clearly more skeptical toward coal than previous administrations, with the president himself ever more frequently accused of waging a 'war on coal'. In 2012, Republican Congressmen even passed the 'Stop the War on Coal Act', which sought to remove regulations on the coal industry. It would always get stopped in the Senate, but it still goes to show some of the political intensity that surrounds the coal industry (Caldecott, 2013; *Economist*, 2014c; Ernst and Young, 2012b).

The Obama administration has also struggled to equivocally turn US energy policy around in other areas. In his 2014 State of the Union address President Obama pledged support for the 'fuels of the future', but this primarily meant an emphasis on natural gas over oil and coal rather than a truly systemic energy shift. He has urged the House and Senate to stop giving huge tax breaks to 'fossil fuel industries that don't need it', implicitly demonstrating the limits of the presidency and his impotency in the face of lawmakers (*environmentalleader*, 2014). But on key issues, symbolic and substantive, the administration has dithered or faced heavy resistance. The Keystone XL Pipeline is one such. Claimed by its advocates to be crucial for US energy security and to provide up to 9000 jobs, the pipeline would transport up to 830,000 barrels of oil sand from Canada to the Mexican Gulf for refining and export. The administration has, however, dragged its feet for five years and seemingly deliberately stalled, refusing to take a decision on whether or not the pipeline should be built, despite strong pressure from the petroleum industry and Republican politicians (and even the State Department concluding that the pipeline will not unduly worsen climate change).[22] Returning the favor, Republicans in 2014 blocked the passage of an energy efficiency bill, which among other things would have imposed tougher emissions standards on coal plants (*Huffington Post*, 2014b; *Reuters*, 2014d; *TransCanada*, 2012).

Finally, solar company Solyndra was hailed as one of the administration's Green Growth flagships. It was the first to obtain a loan guarantee from the American Recovery and Reinvestment Act (ARRA) program, which was a stimulus package introduced in 2009 following the financial crisis, and the future industrial success of Solyndra would be based on its so-called CIGS solar panels representing a major cost advantage over mainstream crystalline silicon panels. However, in 2011 it went bankrupt.[23] Among Republicans, Solyndra became a symbol of government waste and inability to pick industrial winners, even giving rise to the 'No More Solyndras Act' (which would have ended the DoE guaranteed loan program, terminating future support for clean technologies), which passed Congress (by a vote of 245 to 161), but went no further (Mazzucato, 2013). It is clear evidence of the highly politicized environment surrounding US renewable energy policy that a singular company can trigger an actual attempt at creating a law ending DoE-funded clean technology support. Thus, unlike several other countries, the US has no consensus surrounding even the desirability of renewable energy. Even in Norway, in terms of rhetoric, every political party is pro-renewables, even if this has done little to shift policy away from petroleum.

Thus, US renewable energy policy has wavered more than in most countries, and the swings have coincided with presidential swings. This suggests that vested interests have been less a factor than the political inclinations of the presidents. There is, for instance, no doubting the differences between the Obama administration's take on renewable energy and that of the preceding Bush administration. However, there are obvious limits to the changes that even the most pro-renewable administrations have been able to implement, and ironically, the biggest swing away from coal has happened because of breakthroughs in fracking technology and the revolution in shale gas, not from government efforts to push an energy transformation. This suggests that presidents have limited opportunity to steer policies far away from the mainstream. They are curbed by a Senate where the filibuster is being used ever more actively, and US Senators and Congressmen are to a major extent also representing their states, being influenced by local industrial interests, coal among the foremost of these. With a system of government richly endowed in veto points and veto players, it is very hard to muster the necessary majority to veer US energy policy significantly away from the default. Instead, the potential for radical change is to be found within sectors that are relatively sheltered from partisan politics. And these do – to some extent – exist.

The science system: politically sheltered and a force for change?

In the Denmark chapter (Chapter 6), we will see that an entire research cluster has developed around wind power, and that Denmark for several decades already has enjoyed a human capital advantage in wind. In terms of institutionalizing a permanent Danish wind power advantage, human capital might be an obvious place to look. Given what we know about the lack of the institutionalization of any permanent US renewable framework, it does come as a surprise to learn that the US also has a human capital advantage. In fact, the US has the strongest science and technology sector in the world – for a large part government funded – and has been good at connecting academic research with industry and entrepreneurship. It leads the world in clean energy patents by some margin (IEA, 2013b). Thus, the US has been good both at creating new technologies and diffusing and commercializing them, and herein lays probably the greatest strength of US renewable energy, and its greatest advantage compared to other countries.

While the US research sector is not immune to political swings, it is still far more sheltered from such swings, and from vested interest influence, than, for instance, the PTC, which intermittently has been allowed to expire – either on purpose or by political accident – with disastrous consequences especially for wind power. Thus, one of the strongest impetuses for structural change in the US, comes – not surprisingly – from an area that is relatively sheltered from vested interest pressure and in some way lives comfortably on the outside of the vested interest structure. In many ways, no country is better situated with respect to producing the technological breakthroughs that might create a 'green revolution' than the US.

However, despite this the US performance has been uneven. The US was among the first countries to seriously make a push into clean technologies, through the DoE and more recently with the Advanced Research Project Agency – Energy (ARPA-E) (established in 2007).[24] Thus, the first crystalline silicon solar cells were invented in the US in the 1950s and the US also made serious research efforts in wind and solar in the 1980s. Between 1992 and 2012, the DoE spent $1.2 billion in R&D funding for wind energy and $3.4 billion on solar. This increased considerably with the 2009 ARRA stimulus package, of which 11.5 percent was devoted to clean technology investments. Thus, during President Obama's first term, the DoE received more than $13 billion mainly for clean energy technologies and to modernize the energy infrastructure. In 2009, the DoE produced $377 million of funding for 46 new Energy Frontier Research Centers (EFRCs) at universities, national laboratories, non-profit organizations, and private companies. The financial crisis, in combination with a new president who made support for energy research a vital part of his agenda, has vastly increased the US renewable research effort. In his 2010 budget proposal, renewable energy, energy efficiency, climate research, as well as the establishment of ARPA-E were provided an allocation of $150 billion over ten years (Geri and McNabb, 2011; Mazzucato, 2013).

The purpose of ARPA-E is to go for what Schumpeter refers to as disruptive innovations, that is, those technologies that are so radical that they are too high-risk and too early for private investors, but potentially path-breaking and with revolutionary impact if successful. Its initial budget allocation was a useful $400 million (this has later dropped somewhat). It remains to be seen how successful ARPA-E will be. The idea that there is a need for institutions that can research freely without being subject to constraints from the often-conservative energy industry is a good one. However, for practical purposes, it is easy for the market power and conservatism of the energy industry to inevitably push researchers toward projects within the realms of the already existing system, rather than radically different projects. The success of the ARPA-E is contingent on a drift in this direction not happening.

The science system certainly has success stories to show for (Mazzucato, 2013). Some of the most prominent successes of renewable energy have relied heavily on government funding. In the case of First Solar, the US government supported development and commercialization of thin-film technology and even aided in developing the manufacturing process, whereas federal and state incentives made for the growth of a domestic PV market. Many of the company's patents can be linked to earlier DoE research and on research funded by the University of Toledo and the National Renewable Energy Laboratory, and the IEA (2013b, p.123) states that 13 out of 14 US top solar innovations since the 1980s have been developed with government support, with nine fully funded by the public sector. In Mazzucato's (2013, p.129) words: 'The combination of public support and First Solar's current position as a dominant thin-film producer and solar PV cost leader makes its success nearly assured, ...' There are fewer success stories in wind power. Federal research money spent on large, experimental turbines in industrial giants, such as GE, Boeing, Alcoa, and Westinghouse, have produced little to show for. Instead, somewhat similar to Denmark, present-day success stories have been bottom-up, as in smaller turbines gradually getting bigger (Galbraith and Price, 2013). That said GE has patents going back to DoE research and more or less 'inherited' DoE-funded technologies from bankrupted US wind power companies. Similar stories can be told about companies such as US Windpower, Solyndra, SunPower, and Evergreen Solar.[25] These companies do not all still exist and some have ended with fairly spectacular bankruptcies, but the point remains, namely that their rise and promise owed much to a governmentally funded science sector and to a close relationship between academia, government, and industry.

That said the US science system has an uneven record. It has greatly aided the development of solar panels and wind turbines (Geri and McNabb, 2011; Mazzucato, 2013),[26] but it is also what Geri and McNabb (2011, p.145) describes as a blunderbuss: 'It looks impressive from a distance. We fire many policies at our targets ... but collectively they don't form a coherent pattern. In part, that is because the gun must attempt to hit multiple, nebulous targets, some of which are of secondary importance yet have displaced more legitimate concerns.' And some of which have been political in nature, like 'bipartisan support for omnibus legislation'. Or it has been what Mazzucato (2013, p.135) labels a '"fund everything" approach hoping that sooner or later innovative and economically viable energy technologies will emerge.' There is also no doubt that funding for oil, coal, and nuclear is still much higher (Geri and McNabb, 2011; Sovacool, 2008, 2009b).

Finally, while it is often argued that the US has a major advantage in being the foremost venture capital (VC) country in the world,[27] it is not obvious that this has been highly beneficial to renewables. US venture capitalists allocate more money to renewables than the rest of the world together. However, there is little to suggest that in VC, the US has found a reliable substitute for what in other countries is taken care of by the state. VC was peripheral in the success of First Solar, where it only entered at a later stage and for a short amount of time. And in the case of Solyndra, VC proved more disruptive than constructive, speeding up the company's downfall. VC provides young renewable start-ups with capital that they would otherwise find hard to come by. But VC is also fickle and often risk-averse, pulling out at the first sign of trouble, which may typically be when the government fails to uphold its support. Thus, VC goes for safe technologies (or ones heavily backed or guaranteed by the government), not disruptive ones. It does not have the same appetite for risk as the state, and is thus no good vehicle for energy *transformation*, which requires disruptive technologies, and thus a taste for industrial and technological risk (Mazzucato, 2013). Most high-risk, disruptive technologies do not survive, and have a notoriously hard time finding commercial backers. Thus, while US renewables benefit from access to capital, VC is not *the* solution. Rather, what it demonstrates is a US system where the onus is on policies to make renewables competitive and then let the markets take care of the rest, but without much emphasis on programs of deployment so as to create demand and not just supply.

Shale gas and tight oil as X-factor

For many years, experts have been sanguine about the prospects for renewable energy, in the sense that growth within renewables is set to continue at a very healthy pace for decades still to come. But the past couple of years have seen new developments causing new uncertainties. The most obvious of these, and particularly relevant to the US, are breakthroughs in fracking technology, leading to what many have labeled a revolution in shale gas and tight oil.

This is threatening to become an energy game-changer. In 2013, the US surpassed Russia as the world's largest *energy* producer (Blackwill and O' Sullivan, 2014). And the IEA (2012b) has confidently predicted that by 2020, the US will be the world's largest *petroleum* producer, overtaking Saudi Arabia and once again becoming a net exporter. US tight oil production has gone from basically zero to nearly 4 mb/d in only a few years, almost doubling US oil production. Shale-gas production rose by 50 percent a year between 2007 and 2012. Shale-beds now (2013) account for more than half of US natural gas (up from 8 percent in 2007) production and has made it possible for many to believe in a future where petroleum is once again cheap and abundant, pushing prices down and volumes up. US gas prices dropped from $12 per million Btu in 2009 to less than $2 in 2012 (before increasing back up to $4).[28] Because the wells are many and plentiful, capacity can be rapidly expanded or shrunk, potentially allowing the US to become a swing producer of oil and gas, stabilizing supply and prices in the world market. President Obama in January 2012 proclaimed that the US has a supply of natural gas that will last nearly 100 years, and that it will do what it can to exploit this energy (Blackwill and O'Sullivan, 2014; *Economist*, 2012b, 2013d, 2014g; Heinberg, 2013, p.53). Thus, the US shale effort seems to have political backing. As a potential game-changer, this could be seriously bad news for renewable energy, as it prolongs the life of fossil fuel and pushes the need for structural change further into the future.

However, there are reasons to expect that there is a fair amount of hype surrounding this revolution. The fulfillment of this revolution depends both on the extent to which shale turns out to be hype and the extent to which those benefitting from shale gas are able to convince US decision-makers that this is worth sinking politically irreversible amounts of costs into. Shale and tight oil constitute yet another tightly contested vested interest area in the US energy industrial structure. Klare (2013) reports that for every dollar spent on wind farms, solar arrays, and tidal power research, three dollars go into developing new oil fields, shale-gas operations, and coal mines. For fossil fuel interests, making petroleum once again seem like the solution to America's energy problems rather than what is ultimately a sunset industry, amounts to a major energy-political coup. If successful, it constitutes a clear signal that this is an industry that should see new investments and beneficial federal regulations rather than one that is better left untouched. Hence, from the petroleum industry we are fed claims about the US having the petroleum fracking resources of two Saudi Arabias and beyond (Chesapeake Energy CEO Aubrey McClendon), of hundred years of cheap, clean energy, and that fracking can be used to supplant Russian gas in Europe. Energy independence and energy security arguments have been picked up and eagerly peddled by pro-petroleum politicians. Thus, there has been considerable pressure on Congress to authorize exports of shale gas to the EU (Ayres, 2014; *GlobalResearch*, 2014; *Huffington Post*, 2014a).

Can the hype be believed? The jury is still very much out, but most likely, the promise of fracking has been exaggerated by the petroleum industry. If McKinsey is right that by 2020 fracking will boost annual US GDP by 2–4 percent (Blackwill and O'Sullivan, 2014), it will be hard for the US to say no to shale. However, there are major differences of opinion as to how much of the shale resources are recoverable.[29] The main argument against shale gas is that production at the well typically drops off by an astonishing 60–90 percent during the *first year of production* (30–35 percent for tight oil wells, which is still far more than the average of 6–7 percent for crude oil), and typically declines by 80–96 percent within the first three years of production. Thus, to keep producing shale gas at current levels, ever more drilling at ever higher costs will be required. The Bakken field, which is one of the three biggest US shale plays, requires 2500 new wells a year just to keep production up at current levels, and for the US as a whole, more than 7000 new wells will have to be drilled every year to preserve current production levels. The EIA estimates that in order for US reserves to be exploited, more than 400,000 wells will eventually have to be drilled. This is a seriously large number. After considerable initial exuberance, both the IEA and the EIA now downplay the prospects of shale gas and tight oil. The IEA, for instance, says that tight oil 'shakes the next ten years, but leaves the longer term unstirred' (IEA, 2013c, p.3), whereas EIA has slashed by 96 percent its previous estimate for recoverable oil in the Monterey shale reserves in California, earlier considered to be the most promising US shale play, holding two-thirds of US shale oil reserves. It has also revised downward overall recoverable US shale-gas resources by 42 percent, which amounts to 24 years of supply at current rates, rather than 100 (Ayres, 2014; *Economist*, 2014a; *GlobalResearch*, 2014; *Guardian*, 2014b; Heinberg, 2013; *Los Angeles Times*, 2014). Others have estimated that US shale plays will yield the US less than ten years of extra natural gas, that tight oil will peak between 2015 and 2017, and shale gas in 2015. If so, there is little reason to suspect that the US will become self-sufficient in petroleum other than in the short run. For that to happen, production will have to increase dramatically, while new wells are constantly being drilled just to keep coping with the dramatic drop-off rates of existing wells (Aleklett, 2012; *Guardian*, 2014b; Heinberg, 2013; *LMD*, 2013). If so, making massive investments in shale gas and tight oil will be a waste of time and money, and a distraction away from the real energy problems of the country.

While hardly unbiased – their companies stand to lose greatly from a shale revolution – it is worth paying attention to how clearly Gazprom CEO Alexey Miller and Lukoil President Vagit Alekperov suggest that shale is a bubble, hyped by Wall Street and the oil industry, and that the US can always justify this for energy security reasons, but never for economic reasons (*Voice of Russia*, 2013). Capital investments of $42 billion per year in drilling is currently required to keep the production up, but at the current low gas prices, shale gas in 2012 only generated $33 billion in revenues (Heinberg, 2013). The breakeven point of shale gas is probably somewhere between $4 and $8 million Btu. ExxonMobil Chief Executive Rex Tillerson in 2012 famously stated 'We are all losing our shirts today. We're making no money. It's all in the red' (*New York Times*, 2012). If this is true, the oil lobby is doing the US a serious disservice by urging energy policy away from alternative sources and back toward fossil fuels.

While the most optimistic forecasts are most likely something in-between hype and a conscious attempt at bending the US energy discourse in the direction of massive petroleum investments, there is, however, reason to believe that for the next decade, shale is here to stay. In the US, as opposed to Europe, and so far China, shale has won the battle for the decisionmakers' ear. US policymakers are eager to explore the promises of this resource, and if President Obama were not flagging his enthusiasm for fracking, the Republican Party would have been up in arms. With the Republicans, Democrats from fracking states constitute a very vocal pro-fracking faction. In the US, more so than elsewhere, saying no to fracking is politically very difficult (the argument is now also being ever more used that fracking is helping reduce US CO_2 emissions, as it leads to a substitution of gas for coal). It may make the US energy independent in the short run. For renewables it is, however, bound to have negative consequences.

The military as a renewable loophole?

Present-day US politics is to a great extent gridlocked. Especially since the financial crisis, politics has seemed distinctly broken, taking away from the state and the president the ability to think strategically around energy. Also, as the Republican Party harbors a major faction that refuses to even accept human-induced global warming as a scientific fact, renewable energy policy has less favorable working conditions than in many other countries.

However, as the world's preeminent superpower, energy security concerns loom high on the US energy-political agenda. And the argument that renewables will constitute a major part of the energy security solution of the future is one more readily accepted by the DoD than a highly partisan Congress. Thus, for the past few years, the DoD has been one of the most eager proponents of renewable solutions. President Obama's Climate Action Plan includes 3GW of renewable capacity in military installations. In 2013, in New Mexico, the US Army opened what is presently the world's largest low-concentration PV power plant, and the US is also spending heavily on microgrids, smartgrids, advanced batteries, and fuel cells. More than 40 US military bases have operating microgrids or are in the process of installing or planning microgrids. The long-term goal is that future army bases consume only as much energy and water as they produce, as the US seeks to make its bases independent of energy infrastructure outside of the base itself (Closson, 2013; *Defencetalk*, 2013; DeWit, 2013; IEA, 2014a; *Power*, 2012).

Thus, there is one section of the governmental apparatus where politics is *not* broken, and this is the military. While high-flying rhetoric about energy security from present and previous administrations has brought little structural change, the DoD is looking more seriously into renewables than most. Congress may be cutting spending on renewable energy, but since 2006 DoD spending on renewables and efficiency has increased from $400 million to $1.2 billion, with $3 billion scheduled for 2015. The military may seem an unlikely source of green leadership. However, few US actors have more hands-on experience with the present and potential future consequences of global warming, by virtue of having more or less self-sufficient bases in a number of faraway locations and by being involved in combat operations far outside of the US. Extreme weather and climate security risks are defined as global security threats by the DoD, the CIA, and by other national intelligence agencies. Defense Secretary Chuck Hagel in 2014 presented a Pentagon study which upgraded climate change from merely a future risk to a present threat that demands immediate action, building on previous studies that have considered climate change a 'threat multiplier', and renewables and energy efficiency ('force multipliers') a major part of the solution (DeWit, 2013, DoD, 2014; *New York Times*, 2014).

There is also an acute awareness that the DoD is the biggest institutional energy consumer in the world and the largest purchaser of fuel in the US, spending approximately $20 billion a year on fuel, most of which is petroleum.[30] The hike in oil prices increased DoD's oil-related expenditures by 500 percent between 2000 and 2008. Over a year, the cost of a $10 increase in the price of a barrel of oil equals that of purchasing a new naval destroyer. In Iraq and Afghanistan fuel shipments accounted for 80 percent of all supply convoys, and in Afghanistan one out of 24 fuel convoys sustained casualties. Both maneuverability and tactical capabilities have been restricted for fuel reasons (Closson, 2013; *CSI*, 2014). Thus, the DoD wants to minimize risks associated with transporting liquid fuels, oil price fluctuations, and energy security. By 2025, the goal is for 25 percent of DoD power to come from renewables

(*Greentechmedia*, 2011; Lovins, 2010; *Power*, 2012).[31] In addition to this, by 2020, the Marine Corps wants 50 percent of installed energy to be renewable and a 50 percent reduction in gallons of fuel per marine on the battlefield by 2025. The Air Force has a goal of 25 percent electricity from renewables by 2025. For the Navy, 50 percent of its energy need should come from renewables by 2020 (and a 50 percent reduction in petroleum use), which includes an algal-based biofuel initiative that survived a hostile reception in Congress, and which is meant to propel the Navy to a sustainable biofuel 'Great Green Fleet' by 2016. In 2012, the Navy arranged a major naval exercise where all the ships and planes were on a 50–50 blend of biofuel and regular fuel (Closson, 2013; *CSI*, 2014; DeWit, 2013).

By all means, the future of the DoD is not unambiguously lean, mean, and green. Operations fuel will be far harder to replace than fuel for military bases, and combat operations typically account for more than 60 percent of the DoD's carbon footprint. Combat operations are also exempt from any emission reductions commitments. Further, political in-fighting in Congress has also affected the DoD, as a number of Republican representatives have been very opposed to the DoD funding any alternative fuels. Thus, in 2011, Congress took a turn toward CTL, which from an environmental standpoint is a far worse solution than oil, and removed restrictions on the military to use Canadian tar-sands to liquid. With the US having left Iraq and phasing out its operations in Afghanistan and petroleum prices dropping because of fracking, it could be hard to sustain the military effort to move beyond oil (Closson, 2013).

However, while it is hard to foresee the DoD driving a genuine US energy transformation, it is one of the most promising venues for change in the US. The military could not care less about political in-fighting regarding climate change. The military is not part of the vested interest structure that hamstrings renewable energy policymaking in the US, and it has no ideological predisposition against believing in the existence of climate change or the viability of renewable energy. Rather, the military is arguably the largest and most important domestic US actor standing on the outside of, and rivaling, this vested interest structure, and with major political and economic influence and the ability to carry out projects and research on its own. And this it does in cooperation with the biggest and most successful scientific cluster on the planet and in cooperation with the DoD and the DoE. The question is whether climate change will threaten future US energy security and ability to project power, and if the answer is yes, then what may seem like an unlikely source for a US energy transformation may end up being one of the main drivers. Andrew DeWit (2013) even goes as far as to suggest that vested interest-induced gridlock in US renewable energy policy has created its own backlash, in the sense of a drive among non-partisan US elites, the most advanced US research institutions, strategic government agencies, and innovative capital, spurred by the needs of the US military, to circumvent regular politics. He argues that 'technocratically-led effectiveness' by leading US institutions might do more in terms of transforming the energy sector than anything that regular politics can do. A genuine transformation is hard in itself, but US renewable energy policy is currently gridlocked by a system where anything but incremental change is exceedingly hard to push through. And so, there is a willingness to forge trans-departmental research alliances and to cooperate between different federal agencies, the military and the scientific community, whilst hiding away from regular politics. The extent to which this eventually proves a success is hard to know, but it is striking that the US definitely has an actor with a rather profound interest in transforming the US energy system, and that this actor is a bit on the side of regular policymaking and thus may operate at least to some extent in a way that is unimpeded by the vested interested structure.

Conclusions

It is hard to make more than guesstimates when it comes to predicting the future path of US energy and renewable energy policy. There are several reasons for this. First, there is the growing sense of partisanship. The general US policy environment is toxic. The rise of the Tea Party movement has made it far harder for Republicans to cooperate with Democrats in the legislature, and in the Obama administration, all attempts at carving out environmental, or energy policy legislation, have been stymied by permanent minorities in the Senate filibustering and blocking anything but incremental policy change. If within the Republican Party there is no change of heart on energy policy, any major future structural change will be illusory.

A second reason is the many checks and balances in the US system. The US has a number of veto players, witnessed among other things by the fact that legislation not only has to pass through both the House of Representatives and the Senate, where a 60–40 majority is typically required, but the president also has veto powers. The many veto players also mean that the system is easily used and abused by vested interests, which have a multitude of venues and actors that can be targeted for lobbying purposes.

A third reason has to do with the federal structure of the US. In many ways, the US does not have *one* renewable energy policy, but more like 50-something, as in addition to the federal government, each state (and Washington DC) pursue energy, climate, and environmental policies of their own. There is no RPS, FIT, or cap-and-trade on the federal level. However, there are 36 states with different RPS systems, a handful states with FIT or FIT-like systems, and California has a cap-and-trade program. Further, electricity policy is a state rather than a federal concern. Thus, the vested interest battles that utilities have fought in other countries are in the US fought locally, at the state or the regional level. The upside to having 50 states with their own separate policies is that some invariably will be frontrunners, pushing developments not only at home, but potentially in the entire country. The downside is the lack of policy coordination, and the multitude of regulations that has to be negotiated. This is certainly a problem for the utility companies.

Fourth, and final, the US is peculiar in the sense that it has overwhelmingly prioritized technology development over installations and deployment. Thus, the US is to a greater extent than most countries focused on the supply-side rather than on demand. It has relied (so far to a large extent in vain) on its science sector – which for all practical purposes is the most sophisticated in the world, and for a large part government funded – to produce revolutionary technological breakthroughs, in the belief that then the market will take care of the rest. The US has policies that seek to make renewables competitive, but not policies to deploy. In the words of Mazzucato (2013, p.116):

> The ambivalent US approach shows how contradictory governmental initiatives prevent the full deployment of new energy technologies.…The US has taken a 'fund everything' approach, hoping that a breakthrough disruptive energy innovation, that might also be 'green', will sooner or later emerge in labs, and that VCs will appear to finance the leading start-ups and make these innovative technologies commercially viable and eventually widely diffused. This has not been the case, because the development of many clean technologies requires long-term financial commitments of a kind that VCs are not willing or able to undertake.

So, in many ways, to a considerable extent, the US has been doing reasonably well on renewables, but despite itself, rather than because of itself. There has been little predictability to US renewable energy policies, and the support system has been very weakly institutionalized. There have been major swings in policy whenever a new president has been sworn-in, while at the same time presidents have had a hard time escaping from the political and institutional structures that they are also a part of. There is no FIT. Instead, the main federal policy tool has been the PTC, which has been allowed to expire or nearly expire on a number of occasions, creating very obvious boom-and-bust cycles especially for wind power. And, despite all this, on wind turbines GE had the largest market share in the world in 2012, and First Solar currently has one of the highest market shares within PV. The US has the world's second largest wind power capacity and generates more electricity from wind than any other country. And it does respectably well in solar PV, and hosts the world's third largest domestic PV market. It is also number one in biofuel and geothermal energy,[32] which despite not being discussed in this book are highly interesting renewable sources of energy with lots of future potential. The US has the strongest science sector in the world. President Obama most certainly favors renewable energy, and the Clean Power Plan should provide a boost to renewables (even if it is conceivable that natural gas will benefit even more). The renewable energy projects of the DoD and the US military have been relatively sheltered from political bickering and thus have contributed to significant progress. And Ernst and Young routinely names the US as one of the two most attractive countries in the world for renewable energy (the other being China).

Yet, what for all intents and purposes distinguishes the US – negatively – from the other countries in this book is the lack of institutionalization of renewable energy policy, the lack of any predictability on the federal level for renewable support frameworks, and the ease with which policy can be, and routinely is, blocked – often by politicians representing strong state energy interests and who are easily lobbied by vested energy interests – in the legislature. That the US is doing as well as it is says more about the general strength and dynamism of the US economy and of US industrial actors than about the US state. The US will continue to perform well within renewables (bar the odd boom and bust). However, its potential in this area is truly huge, but because of the ability of vested interests to exploit the system's political constraints they are to a large extent still very much untapped.

5
Germany: At a Crossroads, or Social and Political Consensus Setting It on a Course for Structural Change?

Introduction

For years Germany has been one of the frontrunners in renewable energy. Few countries have installed more renewable energy, few have pursued renewable energy policies more actively, and few can show for a more general social and political consensus on the importance of renewables (maybe apart from Denmark).[1] The German feed-in tariff (FIT) has been emulated by a wide range of countries and has up until now been widely perceived as one of the most successful ways of promoting renewable energy. For short, Germany very often looks like the poster child for good and ambitious renewable energy policies.

One could always argue that Germany's precarious energy security situation should make us expect ambitious renewable energy policies.[2] Germany lacks in both oil and gas. It also relies quite heavily on Russia for its gas,[3] which with more assertive Russian foreign policies is becoming more of a concern than it used to be. It does, however, have major amounts of coal, and up until recently had a very substantial amount of nuclear in its energy mix. Thus, the oil crises of the 1970s, which led Denmark toward wind power and Japan to fund solar, in Germany resulted in more coal and nuclear (Chowdhury et al., 2014; Cox and Dekanozishvili, 2014; Schreurs, 2002). Economic development was certainly more important than pollution control. This combined with the fact that Germany is neither particularly windy nor sunny does not provide us with an easy explanation for why the political economy of German energy has as much to do with renewable energy as anything else. In terms of nuclear power, Fukushima hit not just Japan, but Germany as well, triggering the announcement of an *Energiewende* (energy transformation), which will yield a total phase-out of all nuclear power by 2022. In this, Germany has moved faster and further than Japan, despite being neither earthquake nor tsunami prone (Strunz, 2014; Umbach, 2014). Resource endowments certainly cannot explain why Germany has done away with nuclear as well as trying to reduce its dependency on coal. Resource endowments also cannot explain why Germany for the past couple of years has installed more solar PV than any other country.

At 77GW,[4] Germany's total wind and solar capacity is not that far behind the US (86GW). Considering the differences between the two in terms of land area and population, this is no mean feat. In terms of wind power, Germany was the world leader until 2007. Now surpassed by China and the US, it is third, with an installed capacity of 39GW. In PV capacity, Germany has been the world leader ever since 2005, and in 2014 its installed capacity was more than 38GW (PEW, 2014; REN21, 2014). Explosive Chinese PV growth will ensure that Germany will not remain number one for long, but the German PV market has been the single most important factor in driving international growth in solar power, and in terms of solar power per capita, Germany is miles ahead of both China and the US. Worth noting is also that unlike China, the US, and actually most countries, Germany has an almost even share of wind and solar power. Most countries (with the notable exception of Japan) have far more wind than solar. Once again, the German solar effort cannot be for resource endowment reasons. Looking at solar maps of Germany and the US, even the sunniest parts of Germany in southern Bavaria only measure up to Alaska and the Seattle area in the US. And compared to even the most overcast parts of Spain, no part of Germany is even close in terms of solar irradiation (*NREL*, 2009).[5] Thus, despite being the world leader in installed PV capacity, solar resource maps suggest that Germany should really not at all be a prime candidate for such leadership. Explaining this leadership, as well as to some extent the leadership in wind, calls for an explanation that moves beyond resources and instead merges politics and economics.

One part of the story is easy. Germany implemented a FIT, and earlier than almost any other country (the origins of the FIT go back to 1990). It has since been amended, but in terms of installation figures it has been an unmitigated success. It obliged the utilities to buy renewable energy, and it secured priority access to the grid for renewables from an early stage. The FIT is one reason why Germany has gone from a renewable share (including hydro) of electricity consumption of 4 percent in

1996 to more than 23 percent in 2013 (*BMWi*, 2014c; REN21, 2013a; Strunz, 2014)[6] – which is still quite far behind Denmark, but ahead of China, the US, and Japan. Future policies are also ambitious. By 2020, the share of electricity production from renewables should rise to at least 35 percent, by 2030 to 50 percent, by 2040 to 65 percent, and by 2050 to at least 80 percent. GHG emissions have dropped more steadily since 1990 than in most countries (even if they have risen for the past few years) (IEA, 2013a).

In Germany, as in a host of other countries, the electric utilities have been among the most influential energy policy actors. And their opposition against renewables was originally as steadfast here as elsewhere (Cox and Dekanozishvili, 2015; Jacobsson and Lauber, 2006). So, why did vested interests lose out so much more easily in Germany than in other countries? In Germany as well, the utilities had powerful political and bureaucratic allies and were not prepared to give up without a fight. However, a social consensus developed early on, centering on the importance of environmentally friendly policies (first focusing on acid rain, then on climate), in combination with growing skepticism against nuclear. The resistance against nuclear power was picked up by the political parties. The conservative Christian Democratic Union of Germany/Christian Social Union of Bavaria (CDU/CSU) has always been more pro-nuclear than the Social Democratic Party (SPD) and the green party (die Grüne), and still is more supportive of big, conventional energy industry and of the energy-intensive companies, but in 2011, the decision to phase-out nuclear power was taken by Chancellor Angela Merkel of the CDU. At present, the political consensus on abandoning nuclear power is near complete. Also, with respect to the implementation of most of the renewable energy legislation, the difference of opinion between the major political parties has been more about form than substance. Thus, while the SPD has typically been somewhat more pro-renewable than the CDU, the difference has not been huge. This is a policy issue on which most voters agree, and where a number of major industrial actors also keep pushing German governments. Both the SPD and the CDU have argued that renewable energy is good for the environment, for German energy security, that it contributes to German exports, and ultimately to green economic growth. Few countries embraced the idea of *ökologische Modernizierung* (ecological modernization), namely that economic growth and ecological improvements could actually complement each other, earlier than Germany – it is a German term (Cox and Dekanozishvili, 2015; Jacobsson and Lauber, 2006; Jankowska, 2014; Strunz, 2014). Thus, while there are obviously nuances to this story, compared to most countries, Germany from quite early on enjoyed a relatively broad social and political consensus on the importance of renewable energy expansion. This consensus made it harder for the old vested interest structure to assert its power here than elsewhere. Many years of growth in wind and solar has meant that in Germany they both have accumulated political influence and now find themselves at the hub of a fairly powerful renewable energy cluster. Sühlsen and Hisschemöller (2014) goes as far as to suggest that in Germany, renewable energy is no longer a niche player, but has become part of a regular energy regime that balances traditional utilities and renewable energy. Thus, while there may always be political swings and economic ups and downs, renewable energy policies have become institutionalized to such an extent that it is hard to perceive of a future in which renewable energy in Germany becomes significantly less important or less influential.

Granted, here as in most countries, there are clouds on the horizon. The future should not be taken for granted. German renewable energy has to some extent become the victim of its own success. The FIT has massively increased renewable installations, but in the process become rapidly more expensive. In 2013, Germany paid a total of €20 billion in subsidies for renewable energy, rising to an estimated €24 billion in 2014 (*Reuters*, 2014b). This is a huge sum by any standard, and will keep rising unless the system is altered. The Ministry of Economic Affairs and Energy (BMWi) has always been a supporter of green certificates over FIT, and over the past few years, the thinking of the BMWi has won through to a greater extent. The previous environmental minister Peter Altmaier, in 2013, suggested that the *Energiewende* would cost a mind-boggling €1 trillion by 2040 (*Reuters*, 2013a), and German politicians have been reducing the FIT so as to slow down the pace of renewables expansion. This has led to solar installations dropping from 7.6GW in 2012 to 3.3GW in 2013 and 2.5GW in 2014 (EPIA, 2013, 2014a; Burger, 2015; Jankowska, 2014; REN21, 2014; Stegen and Seel, 2014). The German PV market is still large, but its growth has been deliberately reined-in, and from 2014, with the 2014 Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz* (EEG)), wind and solar power were capped at 2.5GW a year. With goals of 80 percent renewable electricity by 2050, there is also no doubt that the electric grid system needs major upgrading. The current system cannot deal with this much renewable energy, and so in addition to an annual €24 billion of subsidies and upward, the grid system would have to be upgraded at a cost many times that amount. Germany has also realized that green growth is often more elusive than hoped for. Thus, especially within solar power, the domestic German market has attracted imports from all over the world, especially China – to paraphrase Mazzucato (2013), everyone has been fighting over the last German customer. With the solar glut caused by Chinese oversupply, a number of highly prominent German solar companies have gone bankrupt, and German PV production is falling rather than increasing.

Finally, German efforts should not be exaggerated. They are impressive compared to most other countries. But with renewable energy (including hydro and biomass) accounting for less than 25 percent of electricity consumption, and 18 percent of final energy consumption, and with coal accounting for 45 percent of electricity consumption (and even rising since the start of the nuclear phase-out) (REN21, 2013a; Stegen and Seel, 2013; PEW, 2014), this does not equate to a structural transformation. Fossil fuels still clearly dominate. And with the recent energy reform (EEG 2014), which represents the biggest policy revision in many years, Germany is gradually turning away from the FIT and toward more market-based energy tools, such as a tendering, or bidding, system, that will start in 2017. The long-term consequences of these changes are still very much up in the air, but the FIT could be on its way out.

Still, renewable progress has been so fast that Germany has already been (almost) able to meet the power gap that resulted from the closure of eight of its 17 nuclear power plants in 2011. This is no mean achievement, and it is realistic that by 2025, when the remaining nine have been phased out, that renewable energy will also be able to compensate for this (Lechtenböhmer and Samadi, 2013). And this has happened because in Germany vested interests were not able to hold their own against a social and political consensus that despite certain ups and downs has been remarkably consistent. What it does, however, also mean is that in terms of producing an emissions-free energy system, the past couple of years have only seen Germany successfully compensate for its drop in nuclear capacity. Thus, neither the fossil fuel share nor the energy self-sufficiency ratio has changed much. And as much as the renewable effort should be lauded, if Germany can only just about compensate for the remaining nine power plants, then by 2025, the fossil fuel share will also not have changed much. Thus, what we have seen so far in terms of structural change is more a change away from nuclear than a change away from fossil fuels.

Renewable energy: FIT providing expansion both in wind and solar

The main policy tool for German renewable energy expansion has been the FIT. The FIT has its origins in the aftermath of Chernobyl (1986) and the work of the German Climate Survey Commission, which along with two demonstration cum market formation programs on the part of the Ministry of Research – the 1989 1000 Roofs Program for solar cells and a program aimed at installing 100MW (later expanded to 250MW) of wind power – created acceptance for renewable energy. Thus, in 1990, Germany introduced the Electricity Feed-in Law (StrEG, or *Stromeinspeisungsgesetz*), initially meant for small hydropower only, but instead heralding the start of more than two decades of German renewable energy support. The law meant that utilities had to connect electricity from renewable energy to the grid and buy the electricity at a rate of 90 percent of the tariff for final customers. The StrEG provided the same payment to both wind and solar, but as in 1990 wind power was far cheaper than PV; it for all practical purposes favored wind quite heavily. In 2000, when the StrEG gave way to the Renewable Energy Sources Act (EEG), Germany had installed nearly 4.5GW of wind power (more than any other country), but only 32MW of solar power (EPIA, 2014a; IEA, 2001; Jacobsson and Lauber, 2006; Jankowska, 2014).

Reform of the StrEG started in 1999, and the EEG was passed in 2000. In the EEG, feed-in rates are guaranteed for 20 years, but reduced by 5 percent every year so as to take into account that over time technological progress should make renewable energy less costly and more competitive. The rates are also up for revision every four years. The EEG maintains that all electricity generated by renewable energy sources receives a fixed FIT, and that the network operators, by law, have to feed this electricity into the grid. The utilities have to purchase, transmit, and distribute all renewable electricity, at fixed prices. The EEG gave German renewable energy producers priority access to the grid, earlier than almost anywhere else, and this has been very important for the promotion of renewables. Most of the extra cost that the production of relatively expensive renewable electricity brings is passed on to the electricity consumers, in the form of a surcharge. Protests against the EEG from energy-intensive industries that worried about the consequences that increased electricity prices would have for their international competitiveness were in 2003 placated by the hardship clause (*Härtefallregelung*). This meant that companies with particularly high electricity consumption (typically the energy-intensive industry) were allowed to cap their additional costs stemming from the EEG surcharge. The EEG has been amended a number of times. In 2004, feed-in rates were increased, resulting in PV installation figures increasing from a little above 100MW a year to close to 1GW. However, toward the end of the decade, as PV prices were rapidly declining and PV installation figures going through the roof, raising the overall electricity costs for consumers and threatening grid stability, the FIT had to come down. This happened with the EEG 2009, and again with the EEG 2010, where further reductions in the FIT were introduced. But annual installations still kept increasing, to a record high of almost 4GW in 2009, only to give way to more than 7GW in 2010, compared to a government target of only 1.5GW. As 2011 and 2012 installation figures remained above 7GW, the EEG saw further revisions. The EEG 2011 adjusted the FIT downward and the EEG 2012 introduced a threshold of 52GW of installed solar capacity (Germany at the time had 32GW). Crossing this threshold would lead to further policy action. The FIT was again adjusted downward, and some market-integration measures were taken, whereby renewable energy producers would be able to sell power directly to the wholesale electricity spot market, instead of to the utilities (Frondel et al., 2010; Jacobsson and Lauber, 2006; Jankowska, 2014; Sühlsen and Hisschemöller, 2014; Tveten et al., 2013).

In 2009, Germany was the global leader in terms of renewable energy investments. And in 2010 German investments peaked at $33.7 billion. However, the EEG revisions and the downward adjustments to the FIT, in combination with austerity measures from governments that have tried to steer Germany through a financial crisis, have led to investor uncertainty. Thus, reductions in German renewable investments mirror developments in Europe as a whole, and so, in 2013, at $10.1 billion investments were less than one-third of the 2010 figure, and down 55 percent even from 2012. Wind fared reasonably well, with a drop of only 16 percent, but is facing ever greater problems finding good, unexploited wind sites, whereas solar faced a drop of two-thirds from one year to the next. In one way the solar drop is not unexpected. Since 2008, more than three-fourths of all renewable investments in Germany have gone to PV, and thus the solar boom was always more vulnerable to a bust than wind (PEW, 2014; REN21, 2013b, 2014).

However, the most dramatic changes to the system were made in June 2014 with the EEG 2014 reform, the consequences of which remain to be seen. The most important part of the new EEG is the phasing out of the FIT, potentially by 2017, with the introduction of a tendering, or competitive bidding, system. While the FIT has led to Germany installing more PV capacity than any other country, the sheer cost, more so the cost of PV than of wind, has made it ever more obvious that the system is becoming very expensive (€24 billion a year in subsidies and a rough estimate of €1 trillion for the *Energiewende* in total), as well as running ahead of grid-line expansions. The variability especially of solar power (wind after all also blows during the night) has proved a major challenge for the grid network, and without rapid upgrades to the net, feeding ever more solar power into the network is simply unsustainable and leads to increased needs for backup base-load power (in Germany typically coal and lignite, which supply more power today than at any time since 2007) and to the dumping of surplus renewable power to other EU countries at heavily discounted prices (despite this electricity already being heavily subsidized through the FIT).[7] Thus, the aim of the EEG 2014 is to bring annual installation figures down to controllable levels (i.e. 2.5GW for both wind and solar), and to pursue the *Energiewende* in a more cost-effective manner (*BMWi*, 2014a; *Greentechmedia*, 2014b, 2014c).

Wind power: stable growth

A German wind power R&D program existed already in the 1970s, with about 40 R&D projects between 1977 and 1989 focusing on the development and testing of small- to medium-sized turbines. The 1980s saw a number of demonstration programs, but by the end of the decade, as the US had a capacity of approximately 1.5GW, Germany had still only installed 20MW (Jacobsson and Lauber, 2006). As described in the US chapter (Chapter 4), the US, for all practical purposes California, was the early runner in terms of wind power. But once the California Wind Rush ended, US capacity remained at a standstill. Thus, from 1997 onward, greatly aided by the Feed-in Law, Germany – at the time with about 2.1GW of capacity – became the world leader. Since the introduction of the EEG 2000, German wind power installations have remained remarkably stable, never going below 1.5GW and, except for 2002 and 2014, never above 3GW in a single year (see Figure 5.1) (compare this, for example, to the busts and booms of the US (see Figure 4.1), or the five-year hiatus in Denmark with no installations (see Figure 7.1) (GWEC, 2014, 2015; IEA, 2000)). Germany is no longer the leader in terms of capacity. It is a small and densely populated country, and cannot realistically compete with the US (which surpassed Germany in 2008) or China (which did so in 2010) in terms of capacity, but at a current 39GW, Germany ranks third in the world, and will remain so for the foreseeable future. In terms of capacity per land area, pretty much only Denmark is ahead. This is also about geographic differences. Germany

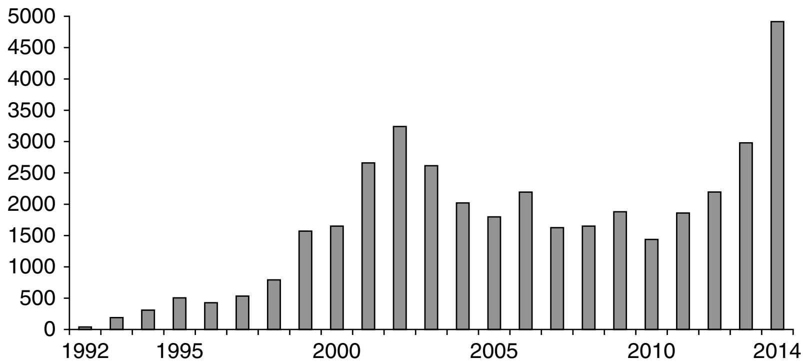

Figure 5.1 Annual German wind power installations, 1992–2014 (MW)
Sources: Calculated from GWEC (2014, 2015) and IEA (2000) figures.

is a federal country, and there are major differences as to how different German states (*Bundesländer*) have emphasized renewable energy. Thus, in 2013 four German *Bundesländer* had enough wind capacity to meet more than 50 percent of their electricity needs (REN21, 2014; WWEA, 2013).[8] With the EEG 2014 reform, installations will now be set at an annual 2.5GW.

Whereas employment in the PV sector has dropped by 50 percent in only two years, German wind power is still going relatively strongly. Employment increased from 101,000 in 2011 to 138,000 in 2013, despite reductions in investment levels. While certainly more robust than solar, chances are, however, that employment will drop in wind as well, and that the good 2013 and 2014 figures had to do with investors rushing installations through before major changes to the FIT were implemented. But Germany is still the strongest European market. Thus, in a Europe where financial crisis is prompting countries to scale back their renewable energy programs, Germany in 2013 accounted for nearly 30 percent of all European installations (EWEA, 2014; McKillop, 2014).

Exempt from the 2.5GW annual target is offshore wind. Here, Germany has for long had ambitious targets, but at the same time offshore growth has remained elusive. The *Energiewende* goal of 10GW by 2020 has been scaled down to 6.5GW. This could also be optimistic, as at the end of 2014, German capacity stands at only a little more than 1GW (most of which is not grid-connected), but 2015 will most likely see 2GW of new capacity commissioned. In terms of offshore human capital, Germany is certainly doing well (Wieczorek et al., 2013). But a 2013 survey among Germany's wind power companies performed by Stegen and Seel (2013) showed that while companies were in general sanguine about the government's onshore wind power goals (apart from worries about NIMBY problems and slow grid expansion), they found the (old) offshore goal of 10GW completely unrealistic (6.5GW slightly less so). Reaching it would require a massive acceleration of installations as the industry is facing serious delays because of technical problems, grid connection problems, and financing problems. The FIT will, however, remain higher for offshore than for regular wind power, and after years of little offshore growth, 2014 may have seen a shift in momentum (*BMWi*, 2014a; *Power*, 2015; REN21, 2014; Stegen and Seel, 2013; WWEA, 2014).

Market contraction and wind power consolidation in Europe, as well as the fact that the Chinese market to an ever greater extent is supplied by domestic rather than Western manufacturers, have led to German wind manufacturers facing the same slow down as the rest of Europe. The year 2013 saw some bankruptcies, but Germany still has some of the strongest wind power manufacturers in the world. In terms of market shares Enercon and Siemens are both in the top five (2013 market shares of 9.8 and 7.4 percent), whereas Nordex is in the top ten. Siemens in 2014 controlled 60 percent of the European offshore wind market. Also, unlike, for instance, Chinese manufacturers, they are not overly reliant on the domestic market. In 2011, Siemens exported 97.7 percent of its production, Enercon 48.8 percent, and Nordex 92 percent (Gosens and Lu, 2014; GWEC, 2014; REN21, 2013a, 2014; *Reuters*, 2014c; Wieczorek et al., 2013). While the consequence of the EEG 2014 and the general drop in renewable investments in Germany since 2010 is that no immediate domestic wind power boom can be anticipated, what remains is a wind power sector that is more robust than most, and with the possible exception of Denmark more robust than in any other European country.

Solar power: rapid acceleration

German solar cell research goes back all the way to 1960, and as in a number of other countries, the research effort was greatly boosted by the 1970s oil crises, and as with wind power, solar received R&D money spread across universities, firms, and research institutes. The first demonstration project took place in 1983, but it was only with the 1000 Roofs Program that anything resembling a domestic market was starting to emerge (Chowdhury et al., 2014; Jacobsson and Lauber, 2006). Still, growth was far slower than in wind power, courtesy of the fact that the Electricity Feed-in Law gave the same feed-in tariff to solar as to wind, despite solar being far more expensive. Thus, in 2000, at the introduction of the EEG, Germany may well have been among the countries with the largest PV capacity, but it was still only 32MW, compared to 4.5GW of wind. It was only with the EEG that growth finally took off, and as the FIT for solar PV remained high at the same time as costs dramatically fell, PV rapidly became far more interesting. Thus, from 2004 onward, the domestic market was the biggest in the world, and in 2005 Germany – at the time with almost 2GW of installed capacity – surpassed Japan, to move into a first place that the country has confidently held ever since. With the exception of 2010, when Italy installed nearly 10GW in probably the most extreme boom and consequent bust in solar PV history, the domestic German market was comfortably the world's biggest (peaking at 7.6GW in 2011 and 2012) until 2013, when it was reined-in by politicians. At 38GW (2013), Germany, which is not even particularly sunny, has installed more capacity than any other country. However, because of lower utilization, solar still accounts for only 4.5 percent of electricity production, as compared to over 8 percent for wind (see Figure 5.2) (*BMWi*, 2014c; Burger, 2015; EPIA, 2014a; Jankowska, 2014).

The German market is still the largest in Europe, but this is much because of the implosion of the European market. In 2011, Europe

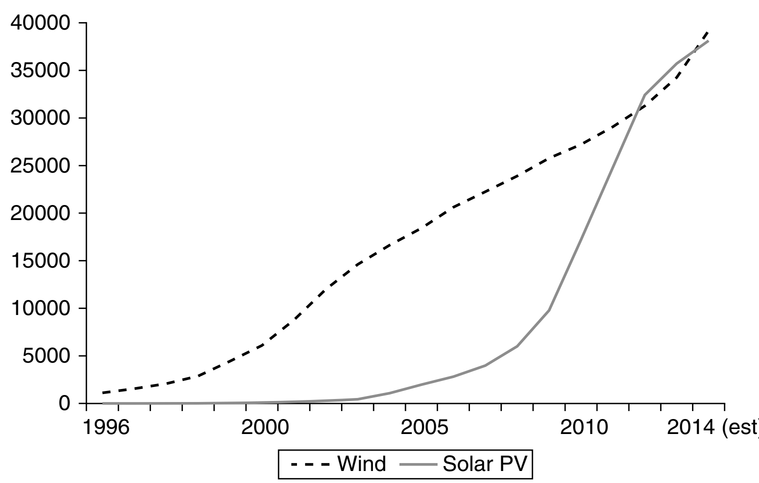

Figure 5.2 Cumulative installation figures for wind and solar power, 1996–2014 (MW)

Sources: Burger (2015); EPIA (2014a); GWEC (2014, 2015); IEA (1999, 2000).

connected 22GW of capacity, then accounting for almost 75 percent of the world market. This shrunk to 11GW in 2013 (less than China), or less than 30 percent of the global market (EPIA, 2012, 2014a). The problem was two-fold. Between 2010 and 2012, when Germany installed more than 7GW a year, this was far more than anyone was prepared for, and something that seriously challenged the capacity of the grid net, as well as drove government expenses up. Second, the expansion was to a large extent driven by cheap Chinese (and Taiwanese) PV, rather than boosting the domestic industry. When German politicians and others argued that the FIT would create green growth and stimulate German manufacturing, the PV industry was very much on their minds. However, in Germany as in the US and Japan, the PV industry has fallen prey to the glut created by Chinese oversupply and low-cost manufacturing. For a number of years Germany was the second largest PV producer in the world, behind Japan, and in 2008 when they surpassed Japan, they were still number two, this time behind China. Between 2005 and 2008, Germany controlled 20 percent of the market, and production increased year by year. However, when production peaked in terms of absolute figures in 2010, the German market share was down to 8 percent, since then, production volumes have dropped by more than 50 percent and the market share to less than 4 percent (*GTM Research*, 2014). For a number of years a lot of countries perceived of solar cells primarily as an export industry and Germany as the primary market. While this led to PV prices declining, from an economic point of view this was a disaster for Germany. And so, with the EEG 2014 reform, PV installations have been fixed at 2.5GW a year.

As a result of the influx of Chinese PV, the once proud German PV industry has suffered a number of high-profile bankruptcies. Prominent firms such as ConergyAG, SolarHybrid, Solon, Solar Millennium and Q-Cells have all closed down. Q-Cells (now owned by the South Korean Hanwha Group) was the world leader as recently as 2008. Bosch Solar and Siemens have both withdrawn from the solar business. At the moment, no German firms are among the largest 15 PV manufacturers in the world, and over the past few years, the number of German PV jobs have fallen from 111,000 in 2011 to 88,000 in 2012, and 56,000 in 2013 (wind power jobs increased from 101,000 to 138,000) (Ernst and Young, 2013c; REN21, 2012, 2013a, 2014). A repeat of the 2010–12 boom is very unlikely, as the decline is a consequence of lowered targets, that is, of a deliberate policy that the major political parties are in agreement on. The German solar sector is so to speak in a state of 'managed decline' (McKillop, 2014).

Vested interests, but with only limited support?

In many ways the German energy vested interest structure was not radically different from that of many other countries. Granted, Germany has never had a petroleum industry to influence energy policymaking, such as Norway or to some extent the US, and in that sense renewable energy has had to face one less rival energy producer than in many other countries. However, Germany has a big coal industry, which is an influential energy-political actor. Denmark reacted to the 1970s energy crises by treating coal as a necessary and temporary evil, as well as by eventually rejecting nuclear. In contrast, in Germany the government *stimulated* the use of non-competitive domestic hard coal, financed through a surcharge on the electricity prices of final customers. Also, it massively expanded research efforts in nuclear power. Coal and nuclear have been the staple food of the German utility companies, which here as elsewhere constitute a powerful part of the vested interest structure. Germany has four major utilities – the 'big four' (RWE, E.ON, Vattenfall, and EnBW) – which control nearly 90 percent of the electricity market (Sühlsen and Hisschemöller, 2014), and which have their own regionally separated transmission networks in a market best described as an oligopoly. In the words of Strunz (2014, p.152), this 'inhibited competition and fostered a very rigid market structure. In sum the fossil-nuclear regime was very resilient for several decades because technological, political and economic structure mutually reinforced each other'. The main political parties were no force for change. On the contrary, support for nuclear and coal was strong with the pre-1982 SPD administration and with the 1982–98 Conservative-Liberal governments comprising the CDU/CSU and the Free Democratic Party (FDP) (Jacobsson and Lauber, 2006; Strunz, 2014).

The attitude of the utilities toward renewable energy was largely hostile. As late as 1993, a statement from the German utility companies said that even in the long run, renewables such as sun, water, and wind could never provide more than 4 percent of Germany's electricity demand. Renewable energy was expensive, and the small and decentralized form of generation so typical of renewable energy would over time also pose a threat to the centralized conventional power generation of the utilities. Even to this day, this is the case. The reluctance with which the 'big four' has taken to renewable energy is evidenced by the fact that only 5 percent of renewable capacity is actually owned by these utilities. The exception is offshore wind parks, in other words projects that require large-scale deployment and large amounts of capital. However, so far, despite lofty ambitions, offshore wind remains a sideshow. The reluctance of the utilities toward renewables was shared by their most important bureaucratic ally, namely the BMWi, which has insisted that energy technologies need to prove themselves in the market rather than rely on subsidies. Thus, here we see a similar emphasis on cost effectiveness as, for instance, in Norway. Germany also had major interest organizations, such as the BDI (the Federation of German Industry), IG BCE (the Mining, Chemical, and Energy Industrial Union), VIK (the German Association of Industrial Energy Users and Self-Generators), VDEW (the Association of Electrical Industry), and the BDEW (the Association of Energy and Water Industries) that saw no reason for any change to the existing energy regime (Ernst and Young, 2014b; Jacobsson and Lauber, 2006; Stegen and Seel, 2013; Strunz, 2014). Thus, on the face of it, the German vested interest structure could easily be portrayed as about as rigid and stable as the Japanese one. Granted, Fukushima has led to major changes in Germany as in Japan, but the German vested interest structure had already been seriously weakened before then, and the notion of an *Energiewende* is actually an old one,[9] and not a term coined because of the disaster in Japan.

Despite the seemingly ironclad coalition of interests supporting the old energy regime, Germany has succeeded in implementing policies that have severely gone against these interests. One could, of course, argue that there would have been no *Energiewende* without Fukushima, and there is a kernel of truth to this, in the sense that the notion of an *Energiewende* has become commonplace ever since. And the changes since Fukushima have certainly been important. By 2022, all of Germany's 17 nuclear power plants will have been phased out. Already eight have been shut down, resulting in the immediate loss of 40 percent of the nuclear capacity, or somewhere between 30 and 40TWh a year. In 2010, nuclear contributed 22 percent to the electricity mix, down to 16 percent by 2012, after the shut downs (Lechtenböhmer and Samadi, 2013; Strunz, 2014). Thus, these are not small amounts of energy. And because the feed-in from nuclear is far more reliable than the feed-in from renewables, for renewable energy to compensate for the loss of nuclear, far more renewable energy has to be phased in than nuclear energy is shut down. Thus, the absence of nuclear almost by default means that major new renewable capacity must be installed. And so far, renewable energy has been able to more or less pick up the slack. Lechtenböhmer and Samadi (2013) predicts that by 2025, when all the nuclear plants have been shut down (as long as current grid problems are fixed), renewable energy will expand to the extent that it covers the power gap left by nuclear.

Despite this, the *Energiewende* is not the reason for German renewable success. In many ways it actually does not represent a momentous shift. In 2010, the CDU/CSU-FDP coalition backtracked on previous policies to extend the lifespan of all German nuclear power plants by 12 years. In 2000, the center-left coalition of the SDP and die Grüne had limited the upward life of each nuclear plant to 32 years, which would have meant a full phase-out by 2021. Thus, when the CDU/CSU-FDP government overturned this, and then less than a year later committed to shutting down all nuclear plants by 2022, this really just constituted a return to previous policies, interrupted by a five-month interregnum. The fact that the *Energiewende* has a consistent support of 80–90 percent of the population suggests that another reversal of policies is unlikely (Lechtenböhmer and Samadi, 2013; Stegen and Seel, 2013; Strunz, 2014).

Thus, we have to look further back for the reason why there was an opposition against nuclear and why renewable energy has been seen as a major part of the solution. Popular protests and the German antinuclear movement go back to the 1970s, and after Chernobyl this opposition became more cemented, losing its political fringe image. Popular opposition to nuclear increased to a steady 70 percent, and the SPD made a commitment to phasing out nuclear power. Only a year after Chernobyl, CDU chancellor Helmut Kohl declared climate change to be the number one environmental problem, and a special parliamentary commission consisting of both government and opposition parties concluded that energy use in Germany had to change. Thus, already by the late 1980s both major political parties were acknowledging that change was afoot (Jacobsson and Lauber, 2006; Stegen and Seel, 2013).

The popular resistance against nuclear still does not explain the implementation of a FIT. Already in 1980, a parliamentary commission recommended renewable energy as the solution for the future, and R&D spending on renewable energy rose manifold between 1974 and 1982, until the course was reversed by a CDU/CSU-FDP coalition. Jacobsson and Lauber (2006, p.261) write that until the end of the 1980s, renewable energy faced a fairly hostile political-economic environment. The utilities were all opposed, and the BMWi and the Ministry of Research and Technology (BMBF) were unhelpful. The latter, while having spent DM13 billion on nuclear RD&D was only allowed by the BMWi to support R&D as well as some demonstration projects. This made commercialization very difficult. At this time, research money for nuclear dwarfed funding for absolutely everything else, whereas funding for research on coal was also several times higher than renewable funding. Still, between

1977 and 1989, enough wind and solar R&D projects at universities, research institutes, and firms were funded that Germany developed a healthy academic and industrial knowledge base on renewable energy. The formation of organizations such as the Institute of Ecology (1977), the Förderverein Solarenergie (1986), and Eurosolar (1988) contributed to building what Jacobsson and Lauber (2006, p.263) label an advocacy coalition for wind and solar power, and over the years, renewable energy research funding kept increasing. Still, comparing nuclear R&D funding from the 1980s to renewable research funding from the 2000s, renewable funding now accounts for half the budget, but before Chernobyl this budget used to be far higher (Frondel et al., 2010; Jacobsson and Lauber, 2006).[10]

In 1990, the Electricity Feed-in Law was introduced. There had been political pressure for such a law for a good while already, but the BMWi was against it, as it favored cost-effective solutions over subsidies, and that renewable energy should be able to compete on its own. However, there was support from the BMBF and from the Ministry for the Environment (BMU), and in 1988 the BMBF had introduced two major demonstration projects that were intended to lead to market formation. One of these was the 1000 Roofs Program. The 1990 Feed-in Law, which was Germany's first FIT, was noteworthy not just for going against the opposition of the utilities, but for being introduced by a CDU/CSU-FDP administration, with support from the SPD and die Grüne (however, both wanted to go further). Jacobsson and Lauber (2006, p.264) note the ease with which the law was passed. It would have major future ramifications, but passing it did not require a massive political effort. However, they also note that from the outset, the law was only supposed to apply to a few hundred MW of small hydropower and thus was not considered a threat, and that since this was in 1990, the utilities were distracted by the fact that they were in the process of absorbing the electricity sector of East Germany. This then sort of flew under their radar (Jacobsson and Lauber, 2006; Jankowska, 2014).

Later changes to the FIT were also by and large characterized by political consensus. In 2000, the EEG was introduced by an SPD-Grüne coalition, and in 2004 the EEG was amended, with more generous feed-in rates. The opposition parties, while clearly less pro-renewable than the new government coalition, were split, and thus posted only muted resistance. Moreover, their resistance was primarily about details, such as the level of compensation for wind and solar. Thus, while many of the politicians from the opposition voted against the EEG and the 2004 amendment, there was still a broad consensus on the substance

(Cox and Dekanozishvili, 2014). Jankowska (2014) argues that it was the SPD-Grüne coalition that was the driving force behind the growth of renewable energy, and that consequent administrations (the CDU/CSU-SPD coalition of 2005–09 and the CDU/CSU-FDP coalition of 2009–13) have been progressively more skeptical, as in particular the CDU/CSU and the FDP have more of an allegiance to big, conventional industry and to energy-intensive companies. Still, while the FIT since 2009 on numerous occasions has been made less generous, this period also coincides with annual installations of PV increasing from 2GW in 2008 to almost 4GW in 2009 and more than 7GW between 2010 and 2012, whereas for wind power installation figures remained stable, or increasing slightly from hovering around 2GW for most years to 3GW in 2013. Thus, the pace of installations has not slowed down (apart from attempts at reining-in the growth of PV), even as the FIT has become less generous (EPIA, 2014a; GWEC, 2014; PEW, 2014; REN21, 2014). While policies may change, the political consensus on renewable energy seems healthier than in most places.

This is not to say that the utilities and others never put up a fight against the FIT. In 1996, through the VDEW, the utilities filed a complaint to the DG Competition (the part of the European Commission that deals with competition law) that the feed-in law violated state aid rules. As a result, feed-in rates were to be lowered, the BMWi only too happy to comply with DG Competition, lukewarm as it was on renewables in the first place. This, however, failed in the German Bundestag, with many CDU/CSU MPs prepared to vote against their own government. In the end, rates remained unchanged. Compatibility with EU rules, more specifically state aid charges, came up again in 2002. However, in 2001, The European Court of Justice had already declared that the EEG does not constitute state aid, and so DG Competition withdrew its objection. Both the BDI and the VDEW were highly critical of the EEG 2000, claiming that it was damaging German competitiveness and driving up electricity prices. And the ecological tax reform of 2000, which spared renewable energy, but levied taxes on gasoline, diesel, heating oil, electricity, and natural gas, conspicuously spared coal. The simple reason for this was the close connections between the coal industry and the SPD (then in power). More proof that there was still life left in the old vested fossil fuel interests was that, in 2003, a hardship clause was included, backed by the BMWi, whereby firms that were unduly harmed (typically energy-intensive firms) by higher electricity prices would get an exemption from the surcharge.[11] The number of companies to be exempted has only kept increasing. Also, the rapid expansion, in particular of PV, has resulted in electricity costs rising to such an extent that measures have been taken so as to slow down PV growth. Altmaier, who was minister of the BMU between 2012 and 2013, was more concerned with cost effectiveness than his predecessor, and clearly more aligned with the BMWi. Thus, he has suggested that the *Energiewende* might cost as much as €1 trillion and that the *Energiewende* should be less of a priority than stable electricity prices. Thus, as the *Energiewende* has become ever costlier, it has also become more open to interpretation with respect to its time schedule and scope. The BMWi, which always favored emissions trading over a FIT, has never changed its mind on this point. Thus, while the German vested interest structure favoring the old fossil fuel and nuclear paradigm has clearly weakened, developments over the past couple of years have swung back in the direction of more traditional energy actors (Jacobsson and Lauber, 2006; Jankowska, 2014; *Reuters*, 2013a; Schreurs, 2002; Stegen and Seel, 2013).

However, in explaining the success of German renewables, it is also important to note that support came from a much broader coalition than just the political parties, making it more robust to changes in political and economic conditions than elsewhere. The shift in attitudes toward environmental protection started already in the 1980s, not just because of Chernobyl, but because of worries about the ozone layer and about acid rain. This among other things led to the 'greening' of the political parties (Schreurs, 2002, p.249), and voters along the political spectrum have in general been pro-renewable energy, even if more so in the SPD and die Grüne than in the CDU/CSU. But the growth of a renewable energy industry meant that the support coalition could broaden also to encompass more industrially minded voices. Thus, the CSU in Bavaria, typically the most conservative element of the German political party scene embraced renewable energy partly because of bottom-up support for renewables and partly because of the industrial opportunities that renewable energy brought to Bavaria (Strunz, 2014). Industrial promotion became an important part of the renewable energy regime. For the SPD, this had been on their agenda ever since the reunification in 1990 made it clear that (East) Germany sorely needed new jobs in new industries (Schreurs, 2002) (Germany now has a total of more than 370,000 renewable energy jobs (REN21, 2014)).

There was also intense lobbying on the part of German companies. One of the arguments was that there was no point in German production if there were no home market. Thus, in the late 1990s, solar cell firm ASE stated that without market expansion in Germany, it would move abroad. Promises of future programs made ASE invest in a plant in

Germany, and shortly after Shell entered the German solar cell industry. These breakthroughs were aided by lobbying from interest organizations such as Eurosolar, Förderverein Solarenergie, and Greenpeace. For the EEG, in addition to these organizations, politicians could count on support from the Association of the Machinery and Equipment Producers (VDMA), the Metalworkers Trade Union (IG Metall), three solar cell producers, and politicians from different German *Bundesländer*, as well as even one of the utilities. In 2003, both the German Confederation of Small- and Medium-Sized Enterprises (BVMW), representing two-thirds of all employment and the service workers' union, joined the coalition of forces promoting renewable energy. A bureaucratic change also took place, transferring the responsibility for renewable energy from the BMWi to the BMU (Jacobsson and Lauber, 2006, pp.267, 269). True, the 'big four' has access to politicians in a way that the renewable energy industry does not, their CEOs having personal relations to the chancellor. They also commission regular energy studies – typically emphasizing the high costs of PV and wind. But while not having the same access, renewable energy companies also very actively lobby, either through personal relationships with MPs or by being knowledge and information providers, seeking as far as possible to have regular and personal contacts with politicians (Sühlsen and Hisschemöller, 2014). And this has been effective. Not only has lobbying been important for the FIT, but it has also spilled over to the EU level. Cox and Dekanozishvili (2015) argue that when the EU in 2009 passed its Directive on Renewable Energy Sources, Germany pushed for it among other things because it sought to provide German renewable entrepreneurs with a pan-European competitive edge, and that the regulatory innovations that Germany promoted for the EU as a whole were really regulations that it had already implemented. Thus, German renewable policies would now be cemented by promoting and spreading the same policies to the European stage.

One of these policies was the FIT. Upon taking over the EU presidency in 2007, Germany actively pushed energy policy, seeking to create jobs and prosperity through an active environmental policy. Sustainable development would go hand in hand with economic development, competitiveness, and employment. However, the European Commission and the traditional electricity industry favored an EU-wide tradable renewable electricity certificate, in other words a market-based solution that would run counter to the FIT (as well as strengthen domestic opposition against the FIT). Germany, in cooperation with Spain, the renewable energy associations, members of the European Parliament, and international environmental NGOs fought against this and for FITs.

First, the renewable industry relied on a FIT for long-term planning. But second, the creation of the Emissions Trading Scheme (ETS) – a single market for emissions trading – might have led to Germany losing control of its domestic market and for less national control over German manufacturers. The experience was that FITs promoted local renewable energy ownership, whereas market-based systems such as the ETS would leave the control with the traditional electric utilities, endangering the position of the renewable energy actors. Thus, the German position was that the FIT led to technological development, innovation potential, and to European (read German) industrial leadership. Germany won this battle, and the notion that a Europe-wide system modeled on the German would favor the German renewable energy industry and protect its leadership was certainly an important reason why it fought so hard for country-specific FITs as the main renewable energy policy instrument (Cox and Dekanozishvili, 2015).

Environmentally, but not economically, sustainable? Old vested interests striking back?

One should always be cautious about making overly strong inferences from very recent events. In the above section, I have provided an image of German renewable energy policies as among the most progressive and pro-active in the world, driven by both a popular consensus and a rough political consensus, and with strong industrial and institutional interests providing further strength to the German renewable energy coalition. That said there are now greater doubts about German renewable energy policy. Granted, the reductions to the FIT from 2009 onward were sensible, there was not much political disagreement surrounding them, and they did not lead to much, if any, slowdown in installations. However, the worry that the *Energiewende* was becoming too expensive, and only going to become more expensive as more renewable energy was phased in, has become ever more widespread.

The year 2013 saw a steadily shifting energy policy focus, and the CDU/CSU-SPD grand coalition that came to power that year seems to very much carry on the work started by the outgoing CDU/CSU-FDP coalition. In this respect, bringing the SPD, which traditionally has been more pro-renewables than the CDU/CSU, into the government has not made for any policy changes. As mentioned earlier, BMU minister Altmaier brought environmental policy more in line with BMWi policy. But with the 2013 election, the responsibility for renewable energy, which had belonged to the BMU since 2003, was moved to the BMWi, which now has become the Ministry of Economic Affairs *and Energy*. This is a potentially significant change, and means that renewable energy (and climate) policy is now no longer part of environmental policy, but of economic policy. Thus, the entire *Energiewende* has become a part of economic policy rather than environmental policy. This reflects the mutterings of Altmaier from the days when the *Energiewende* was still the brainchild of his ministry, namely concerns about expenses, time, and scope.

Since the CDU/CSU and the SPD are now reigning together in a grand coalition of the two big parties, more or less by definition policy is consensual. Both the BMU and the BMWi are led by SPD ministers, and BMWi Minister Sigmar Gabriel in 2014 stated that Germany has 'reached the limit of what we can ask of our economy' (*Reuters*, 2014b), referring to the €24 billion annual cost of renewable subsidies and emphasizing that Germany had essentially financed the learning curve on renewables for the rest of Europe. Gabriel went further in taking a pro-industry stance than both his CDU/CSU and FDP predecessors, while at the same time maintaining that the *Energiewende* 'has the potential to be an economic success, but it can also cause a dramatic de-industrialization of our country', and that 'we must make the energy shift an economic success' (*Reuters*, 2014b). The CDU/CSU and the SPD have actually declared that they will increase the contribution of renewable energy compared to earlier goals, to 40–45 percent by 2025 and 55–60 percent by 2035. How this will happen is not clear, but the current fear is that present regulations are too expensive, increasing electricity cost to such an extent that German industry is rendered uncompetitive – 2100 companies currently enjoy exemptions from the surcharges,[12] and Gabriel has explicitly stated that unless energy-intensive industries are shielded from the EEG, Germany will lose some of its biggest industries. Further, the concern is that present regulations bring no particular benefit to German industry, and that the electricity grid is not able to accept the amount of renewable electricity produced on particularly windy or sunny days. If too much power is produced, wind turbines have to be shut down – while consumers are still being charged for the electricity that is now *not* being produced, but theoretically could have been, or Germany exports its hugely subsidized renewable electricity to other countries at heavily discounted prices. Whereas on those days when the supply is scarce, coal power plants have to be fired up to fill the power gap – which, for instance, led to 2012 CO_2 emissions increasing compared to 2011. This can hardly go on indefinitely (Ernst and Young, 2014a; *Forbes*, 2013; *Power*, 2014c; *reneweconomy*, 2014a; *Reuters*, 2014a; *Spiegel*, 2013).

Thus, one of the consequences of the EEG and the *Energiewende* is that Germany currently has the most expensive electricity in Europe, and that normal households have seen prices doubling since 2000 (*Spiegel*, 2013). Even within the renewable energy industry, there is a growing awareness that the system is becoming expensive to such an extent that a revision is necessary, and that companies need to become competitive on their own, rather than rely on subsidies (Sühlsen and Hisschemöller, 2014). That a number of companies have managed to lobby their way around increased electricity prices – by claiming that high costs are rendering them internationally uncompetitive – means that the FIT also leads to major redistribution, and that regular consumers are the ones paying for the surcharge, which has increased from €8 billion in 2010 to €24 billion today (*Greentechmedia*, 2014c; *Reuters*, 2014b).

Thus, the number of critical voices against the FIT has been increasing. Much of the criticism is not new *per se*. It is, however, now – as the costs of the *Energiewende* are starting to show, in combination with a Europe that is still in the throes of economic recession – that the realization is spreading that the system may not be viable. Some of these voices argue that massive expenditures have held little promise in stimulating the economy or in reducing CO_2 emissions, and that its effects on innovation have also been dubious. First, while it is true that Germany has some 370,000 renewable energy jobs, it is impossible to say how many jobs have been lost because of higher electricity prices and reduced competitiveness, and as in other countries, the hoped-for industrial growth has been tempered by the fact that in PV most of the growth has been eaten up by Chinese and Taiwanese imports, whereas German companies have gone bankrupt or exited the PV sector (Frondel et al., 2010; REN21, 2014).

Second, while renewable energy has largely been able to fill the power gap left by nuclear, this has not been able to prevent Germany from now deriving *more* electricity from hard coal and lignite (brown coal) than at any stage since 2007 (currently above 45 percent of electricity production), and that no reduction in lignite-produced electricity is in sight. Granted, this is also because of high natural gas prices leading to natural gas being abandoned in favor of far more polluting lignite and coal, and because Germany does not want to become overly dependent on Gazprom in Russia. And because fracking in the US is sending coal prices down, coal becomes even cheaper relative to natural gas in Germany. But also, the variability in the supply of solar means that as solar is phased in, Germany needs more coal power as a base-load, and coal is the preference both because it is far cheaper than natural gas and because

Germany is far more abundant in coal than in natural gas, which has to be imported. In early 2013, utility company E.ON was told that the operating license for some of its oldest and most inefficient coal plants would expire and that the plants would have to be shut down. However, later that year, E.ON was told that the plant had to be reestablished so as to maintain grid stability. This despite the fact that coal plants are far less flexible, operate at a lower efficiency level, and emit far more GHGs than gas-fired plants. Thus, the renewable expansion in combination with a nuclear phase-out is providing a major stimulus for coal. Further, it is also argued that because Germany at the EU-level is trapped within the ETS, the net effect of the emissions cuts within Germany is zero on a EU-wide level, as German renewable electricity production reduces the need for emissions reductions elsewhere (*BMWi*, 2014c; *Forbes*, 2013; Frondel et al., 2010; Leepa and Unfried, 2013; McKillop, 2013; *reneweconomy*, 2014a; *Spiegel*, 2013).

Third, the argument is also that Germany has really been stimulating the least-efficient renewable energy technologies. In one sense this is an unfair criticism, as this is exactly the purpose of a differentiated FIT, namely to recognize that some technologies are less mature than others, and that they thus need higher subsidies so as to have any hope of actually maturing and becoming more efficient and cheaper in the future. However, over the past few years PV has become radically cheaper, whereas the reductions to the FIT have been slower. Thus, what has happened is massive investments in and deployment of PV, that is, in the most expensive type of renewable energy (in a country that is not even particularly sunny). PV, which produces only about 20 percent of the renewable electricity, accounts for more than half the electricity surcharge. Also, according to this line of reasoning the degression rate in the FIT system, which means that each year, subsidies decrease by 5 percent, so as to take into account the expectation that technologies will improve and become more competitive, has the opposite effect: If you know that by installing renewable power next year instead of today you will get a subsidy that is 5 percent smaller, this incentivizes you to implement the existing technology immediately, so as to cash in on a subsidy that is typically guaranteed for 10 or 20 years, instead of waiting to install until the technology has improved. Thus, the criticism is that Germany's highly lauded FIT system encourages installment of renewable energy rather than technological improvements (Frondel et al., 2010; Haucap and Kühling, 2012; *Spiegel*, 2013).

Therefore, the irony is that as Germany is looking to improve on its existing system, a German government commission in 2013 instead suggested emulating the Swedish green certificate system (which Norway is now a part of), and that Germany ought to impose a green energy quota on energy providers, then increasing this quota if more ambitious energy goals were to be pursued (Monopolkommission, 2013; *Spiegel*, 2013). The Merkel administration has since then proposed to phase out the FIT altogether, and instead replace it with a tendering, or a competitive bidding, system, whereby the government auctions off contracts so that producers can generate the capacity that is being specified by the government (*Greentechmedia*, 2014d; *RenewableEnergyWorld.com*, 2014a).

Thus, after much and heated debate, in June 2014, the EEG reform bill passed through the German Bundestag, with the result that the FIT may actually be phased out already by 2017. For now it is merely being reduced (although quite severely, from an average of €0.17/kWh to an average of €0.12/kWh by 2015). The new EEG also sets corridor targets for the installation of wind and solar, with 2.5GW of gross PV installations and 2.5GW of net wind installations, whereas for offshore wind, the target has been adjusted downward and fixed at 6.5GW for 2020 (down from 10GW) and 15GW for 2030 (down from 25GW). However, the big change is that by 2017 Germany will introduce tendering in an effort to make renewable energy policy more market-based and more cost-effective. The test-bed for the tendering system will be a pilot program for ground-mounted solar. If the experiences harvested from this program are such that they can, and should, be transferred to other renewable energy technologies, then Germany will shift from a FIT to a tendering system by 2017. This still does not mean that the days of the FIT are necessarily numbered. So far, only a pilot tendering system has been introduced, and another EEG reform (presumably in 2017) will have to be agreed upon before the FIT is eventually phased out. This could easily be affected by election campaigns, pressure from different *Bundesländer*, some of which are not happy with the reform, renewable energy interest group lobbying, and so on. Thus, the final decision has been pushed into the future, but the general direction is pretty clear, and for now, it is one that both the CDU/CSU and the SPD endorse (*BMWi*, 2014a; *Greentechmedia*, 2014d; *Power*, 2014e; REN21, 2014).

Also part of the EEG 2014 is the mandatory market integration of renewables, whereby new installations above a certain size (100kW from 2016) will be obliged to market electricity directly (*BMWi*, 2014a; Ernst and Young, 2014a). Now, this will not make the German system cost-effective overnight. For instance, as late as 2009, the FIT for solar PV was €0.43/kWh, and since contracts typically have a 20-year duration, if you had installed your solar panel in 2009, you will keep receiving €0.43/kWh until 2029, even though the current FIT is now down to €0.12. Thus, costs will linger on in the system for years still to come (*BMWi*, 2014a; *Greentechmedia*, 2014b, 2014c).

So, does this constitute a breakdown in the renewable energy coalition that has so successfully driven renewable developments in Germany, and a victory for the old fossil fuel vested interest structure? Or is this just a matter of the *Energiewende* taking a different and highly necessary turn, saving the program from faltering under its own expenses? Both the CDU/CSU and the SPD strongly emphasize that the *Energiewende* is still very much on, and that Germany will still reach its highly ambitious goals, just that the reform ensures that this now happens by other and more cost-effective means and with more government control over the process, among other things securing that generation does not keep running ahead of grid expansion. The consensus is, however, not unanimous. Die Grüne opposed the change as an attack on the *Energiewende*, and as something that will not lead to lower electricity prices, but just benefit the fossil fuel industry, including coal, and that Germany has now capped its renewable energy production so that it will only replace nuclear, and not lead to anything along the lines of an actual energy *transformation*. The German Renewable Energy Federation (BEE) has accused the government of caving in to conventional energy producers and that this will also increase the dependence on Russian gas. National solar trade group BSW-Solar has warned that this will lead to the collapse of the German solar industry, hitting homeowners and small businesses the hardest, while sparing the energy-intensive industries (in particular coal), and has with the Federation of German Consumer Organization vowed to challenge part of the new EEG in court. The president of the Federal Wind Energy Association (BWE) called the reform highly unsatisfactory, making long-term planning far more difficult (*BSW*, 2014; *BWE*, 2014; *Power*, 2014d; *PVTech*, 2014; renewableneenergyworld, 2014a; *Solarserver*, 2014).

While Germany is still serious about renewable energy, one of the obvious side effects of the EEG reform is that it plays more into the hands of the 'big four'. The reform has been strongly backed by the industrial lobby. The BDI has, for instance, lobbied for an end to the FIT, and has been supported by the VCI and the BDEW. The FIT provided small enterprises and citizen cooperatives with investment security. With the bidding system, we are instead looking at large investments without the long-term security of the FIT, which means that small enterprises will no longer be able to take the risk of investing in renewable energy. The mandated direct marketing may also mean higher risk, thus disproportionately harming the smaller producers, which now have to do their own marketing, market analyses, and so on (most onshore wind farms already do this). Thus, in all likelihood, what the revised EEG does is tilt the balance of the political energy economy back toward conventional energy producers and the utility companies (*Bloomberg*, 2013b; *Power*, 2014e; renewableneenergyworld, 2014a; *Solarserver*, 2014). The fact that the EEG 2014 is still subject to renewal before the FIT is inexorably phased out, and that no attempt to introduce an energy quota system has been made, also mean that the reform does seek to strike a balance that takes into account the interests of Germany's many renewable energy actors. It is by far too early to say how this will turn out, but that this represents the potentially biggest change for several decades is beyond doubt.

As suggested in the Introduction chapter (grid parity section), the tilting in the balance in favor of conventional energy is potentially, however, countered by the so-called *prosumer* revolution, which has progressed farther in Germany than anywhere else. Almost 30 percent of the German PV capacity is residential, and the 'big four' owns no more than 0.2 percent of the PV capacity. Thus, despite the EEG 2014, the 'big four' has consistently lost market shares and political influence. In 2010, 51 percent of the installed renewable electricity capacity was owned by private persons and farmers, and a total of nearly 1000 energy cooperatives constitute a potentially powerful new renewable energy interest. For Germany, with its high electricity prices, retail grid parity for individual consumers was achieved already in 2012, and so it makes good sense for consumers to become prosumers, that is, produce their own electricity rather than purchasing it from the utilities, and Germany already has as much as 1.4 million PV producers. While the prosumer revolution is not yet upon us, Germany is where the likelihood of it unfolding is the greatest, and if so, it could seriously threaten the incumbent and for the past century completely dominant centralized mode of electricity distribution represented by the utility companies, challenging the control of the 'big four'. Thus, E.ON, which is the biggest of the utilities, is also the first to have taken major steps to adapt to a changing future. In late 2014 it announced that by 2016 it would split itself up. Its nuclear and fossil fuels business will be separated out, whereas the main company will focus on renewables, distribution and marketing, including smart-metering. RWE is considering a similar move (*Bloomberg*, 2015b). Granted, the long-term consequences are highly uncertain – both of the prosumer revolution and of E.ON's change of course – and politicians would no doubt make attempts at controlling the process, but as Germany is reining-in renewable energy with the EEG 2014, it is worth noting that there are bottom-up processes that are pulling in the opposite direction, threatening to accelerate developments instead (Debor, 2014; IEA-RETD, 2014; Schleicher-Tappeser, 2012).

Conclusions

This chapter would have been far easier to write a couple of years ago, and it could also be that it will be far easier to write in a couple of years. A few years ago, this would have been a chapter about the storming success of the German FIT, emulated by countries everywhere, leading Germany toward record installations in solar PV and very steady and impressive figures for wind. And it would have been easy to celebrate (some) German *Bundesländer* deriving more than half their electricity from wind power, not just on good days, but on average, in a renewable energy display that few countries could rival. It would also have made sense to talk about how renewable energy success was a consequence of a firm social and political consensus as to the importance of climate change and to the phasing out of nuclear energy, and that this consensus had been so stable for so long that in Germany, unlike elsewhere, the old vested interest structure grounded in an energy regime based on nuclear and fossil fuels had given way to a renewable energy coalition consisting of the renewable energy industry, renewable energy industry associations, research institutes and academics, German *Bundesländer*, private consumers, and a very healthy percentage of influential politicians within all the major political parties. The conclusion that in Germany the old vested interests were never completely as strong as in other countries, and that they rapidly weakened as Germany ever more eagerly pursued non-nuclear and non-coal solutions would have seemed more or less wholly justified.

And, by all means, German renewable energy has achieved much. For years, Germany has been maybe *the* paradigmatic star on the renewable energy sky. It even drove EU policies, most likely both for idealistic reasons and because of a strong perception that German renewable energy policies and industries would gain from a EU framework that emulated the German. The *Energiewende*, marketed by Angela Merkel after Fukushima, gave even more impetus to renewable energy policy as nuclear energy used to account for more than 20 percent of Germany's electricity mix and now has to be replaced by renewable energy (or alternatively coal and lignite). And as several authors have suggested (e.g. Strunz, 2014; Sühlsen and Hisschemöller, 2014), in Germany it is not the case that renewable energy fights an uphill and often futile battle against the might of coal, petroleum, or nuclear, but rather that the renewable energy coalition has eventually become so strong that it constitutes a powerful vested interest. Thus, in Germany, renewable energy is not a niche player, but a regular part of the present-day energy regime, not just energy-political window-dressing, and something that genuinely balances the traditional utilities and the coal industry. The renewable energy coalition not only consists of industrial interests, but it also includes academics and research institutes, which provide decisionmakers with knowledge, analyses, and factual information, in addition to the lobbying that the industry and its interest organizations have successfully carried out. Thus, for short, a very robust social and political consensus and a very broad renewable energy coalition is what has enabled the rise of renewables. This has made it possible for political decisionmakers to stake out an energy-political course at the expense of old and established vested interests. These may not have been as strong as in other countries – Germany, for instance, has no petroleum industry – but coal has been a German energy-political pillar for decades (not to say centuries), and especially the SPD has been a strong supporter of the coal industry (whereas the CDU strongly backed nuclear). Thus, it was by no means a given that Germany would become the world's renewable frontrunner.

All of this used to be true. By all means, it still is. It is only a few years since Chancellor Merkel proudly announced the *Energiewende*. Thus, the *Energiewende* represents lofty ambitions for German energy and climate policies, and it does so today, as it did in 2011. Still, German energy policies now stand at a crossroads. True, on multiple occasions since 2009 the FIT has been made less generous, among other things in an effort to rein-in an uncontrolled acceleration in PV installations. But from 2013 onward it has been impossible not to notice a very clear change in the energy-political rhetoric – from pretty much every political party but die Grüne. The previous environmental minister Altmaier (CDU) has talked about how the *Energiewende* might cost as much as €1 trillion, and that Germany needs to reevaluate the scope and means of the transition. And present minister of industry and energy Gabriel (SPD) is talking about how the *Energiewende*, which he does profess his commitment to, needs to be made cheaper, more cost-effective and not lead to the de-industrialization of Germany. Thus, the rhetorical emphasis now is ever more on finding ways to make the *Energiewende* cheaper. The potential crossroad came in June 2014, when the Bundestag passed the EEG 2014 where Germany waves goodbye to the FIT system that up until now has been so successful in phasing in renewable energy and instead switches to a tendering, or a competitive bidding, system, in other words a market-based policy instrument. A pilot tendering system starts in the fall of 2014, and if successful, and a new EEG reform can be passed (presumably in 2017), then by 2017 the FIT could be a thing of the past. Thus, when I started this conclusion section by saying that this chapter probably would also be far easier to write in a couple of years, it is because the implications of these changes, and the extent to which the proposed changes will actually happen (much can happen between now and 2017) are still quite unclear. The renewable energy industry and interest organizations, as well as die Grüne see the reform as a betrayal of the *Energiewende* (*das Ende der Energiewende*, that is, the end of the energy transformation) and as playing straight into the hands of the utilities and the coal industry. And the energy-intensive industries have pushed strongly for such a reform for years already. Thus, this could be seen as evidence that there was still lots of life left in the old vested interests, and that when push comes to shove, economics still trumps environmentalism. At the same time, even within the renewable energy industry, there was a growing realization that the FIT had become too expensive and that major changes were necessary. Installations were running ahead of grid expansion, causing intermittency problems and destabilizing the net, the FIT was becoming extremely expensive, and despite the German wind power industry being a major export industry, arguments about green growth look distinctly shadier once we remember that the enormous PV growth over the past couple of years has coincided with a massive influx of Chinese installations, while the production of German PV has actually decreased. And so, while these recent changes to German renewable energy policy have benefited the utilities and most likely harmed the renewable energy industry, the political consensus around this change has been broad, and the feeling is that change has been brought on primarily by necessity. The commitment to ambitious climate and energy goals remains unwavering, and while renewable energy investments have recently plummeted due to uncertainties about the future, Germany will most likely remain among the leading proponents of renewable energy in Europe. The much hailed and announced process of structural change will continue, albeit at a somewhat slower pace. And if Germany strays too far away from that course, renewable energy interests, in conjunction with public opinion, ought to be strong enough to put Germany back on course.

6
Denmark: An Energy Transformation in the Making? Wind Power on the Inside of the System

Introduction

This book analyzes six different countries in six chapters. Thus, countries can be compared to each other, but the chapters can also be read as standalone case studies. One of the more obvious comparisons that can, however, be made is between Denmark and Norway. They are both Scandinavian countries, they are small compared to the other four countries in the book – each inhabiting only a little over five million people – but technologically and economically highly sophisticated, and they are politically fairly similar. In terms of energy policy, they have, however, gone their very separate ways. Some of this is for obvious reasons. Denmark is one of the flattest countries around and does not have much hydropower potential, and it does not have the same abundance of petroleum as Norway. It does hold some petroleum reserves, but these were discovered late and are of a magnitude that allows Denmark to be self-sufficient, but not a major exporter.[1]

Thus, when oil crisis hit the world in 1973, Denmark was in a very different situation than Norway. It faced a choice between importing its energy (typically coal from the European Continent) and finding alternative means of production. The electric utility companies immediately wanted to spring for nuclear, and rapidly identified possible locations. This, however, triggered an anti-nuclear movement, which received widespread popular support (IRENA-GWEC, 2012). With nuclear power a political taboo, and without almost any hydropower, energy-security concerns thus set Denmark on a very different course than, for instance, Norway. This course would make Denmark the frontrunner in wind and one of the world's major wind power producers, fostering the industrial giant Vestas, which from 1999 to 2011 enjoyed an uninterrupted run as the world's biggest wind power company (EPIA, 2013; Nielsen, 2002).[2] Quoting the IEA (2006, p.98), Denmark 'engaged in what is probably the most ambitious support scheme for renewable energy technologies ever seen'. Energy technology and equipment currently constitute 9.5 percent of total Danish exports (IEA, 2011a). At 13TWh of electricity a year and 39 percent of the electricity consumption,[3] no country has a relatively larger wind power sector, and including biomass, close to 50 percent of electricity consumption stems from renewables (DEA, 2012, 2013; *Energinet.dk*, 2014, 2015; EWEA, 2013; REN21, 2013a). While total installed capacity at almost 5GW is dwarfed by a number of countries (Denmark is the smallest country in this book by area – the US and China are more than 200 times bigger), Denmark has the largest wind power capacity per capita and bar Lilliputians Guadeloupe and Aruba it also has the largest wind power capacity per square kilometer (GWEC, 2014; WWEA, 2013).

The combination of oil crises and nuclear aversion made it possible for Danish governments to link renewable energy policy and industrial policy in a way that never happened, for instance, in Norway. Denmark did not end up with a vested interest structure favoring petroleum. Instead, it has come far closer to developing a wind-industrial complex. The Danish wind industry is one of the country's biggest export industries. Wind power has enjoyed the favor of the state and has been able to influence the decisions of the state when these have gone against it. It has itself become an important vested interest, wielding significant influence over politicians and decisionmakers when it comes to energy policy – more so than probably in any of the other countries in this book. And as climate change has become an ever bigger political issue, Danish authorities have sought to link renewable energy promotion with the fulfillment of Danish climate goals (IEA, 2011a; Pettersson et al., 2010; Sovacool, 2013). Thus, Denmark is promoting a number of highly ambitious policies. The Danish parliament has recently decided for the Danish energy system to be fossil-free by 2050. This stems from a 2011 government plan by the name of *Energy Strategy 2050*, which lays out a number of different steps. The first of these is already in the process of being implemented, more specifically an increase in wind power production from 25 to approximately 50 percent of electricity demand by 2020, and more than 35 percent renewable energy in final energy consumption. Plans for 2012–20 are quite detailed and based on a political consensus consisting of all the political parties in the parliament, except one. And again in 2014, broad political consensus led to a climate law, whereby Denmark commits itself to reducing its climate gas emissions by 40 percent (since 1990) by 2020, reiterating the goal of no fossil fuels in the energy system by 2050 (*BT*, 2014; DEA, 2012; IEA, 2011a; Lund et al., 2013).

By all means, not everything is simple and easy. We should not paint a rosier picture of Denmark than is warranted. Danish wind power policy has had its stops and starts. Wind power came to a complete standstill during 2001–08, as more market-liberal policies put an end to renewable expansion. This was a political change that the wind power lobby was unable to prevent. Thus, while more powerful than in most countries, for as long as it lives off subsidies wind power will always be vulnerable to political change. Its strength was, however, one of the most important reasons why policy again turned in its favor. Wind power has always had a number of supporters within the Danish parliament, and its institutionalization within the Danish energy system, the lack of a powerful oil lobby to counter it, the coordination of energy policymaking in a Ministry of Climate, Energy, and Building, and the number of companies and jobs connected to Danish wind power have made it a lot harder to go against wind in Denmark than virtually anywhere else. Thus, in terms of structural change, Denmark is one of the frontrunners among industrialized countries. While Denmark still has one of the biggest carbon footprints per capita of any country (it is after all one of the world's wealthiest countries), the degree to which Denmark has undergone structural change in its energy system is greater than for most. It took Denmark only five years from 1973 to go from being 95 percent dependent on oil for electricity to only 5 percent (Sovacool, 2013). Granted, to a major extent, oil was replaced by coal. But this is still testament to how rapidly it is actually possible to change an energy structure within existing political and economic frameworks.

Danish wind has grown economically and politically so influential that the belated rise of a petroleum industry has had very minor effects compared to in Norway. Sovacool (2013) describes Danish energy policy between 1973 and 1998 as 'remarkably consistent'. With the exception for the years between 2001 and 2005, renewable policies have been predictable, with 25 years of broad parliamentary consensus. To a far greater degree than in most countries, energy and environmental policy have been linked, to such an extent that wind power itself has become a strong structural force. Thus, in Denmark, vested interests stir on wind power policies rather than working against them.

Renewables

One fairly intuitive default expectation about renewable energy policy is that the countries with the biggest unresolved energy problems and the ones with the biggest (easily) exploitable renewable resources are the ones that will have the most ambitious renewable energy policies (e.g. Eikeland and Sæverud, 2007). The lack both of strong rival fossil fuel providers (even taking the late growth of a Danish petroleum industry into account) and of nuclear, the almost complete absence of exploitable hydropower, and the abundance of favorable wind conditions make Denmark a prime candidate for ambitious renewable energy policies. And, as mentioned earlier, Denmark has undergone a more profound structural change to its energy system than most industrialized countries.

In 1980, Denmark's self-sufficiency in energy was only 5 percent. This increased to 52 percent in 1990 and peaked at 155 percent in 2005. Wind power is not the sole reason for this, but its share of domestic electricity demand over the same time period increased from 0.0 percent in 1980 to 2.0 percent in 1990 to 39.1 percent (and still rising) in 2014 (*Energinet.dk*, 2015; REN21, 2014). Thus, wind power is part of the reason why Denmark has very rapidly become one of the most energy-secure countries on the planet (becoming a petroleum producer is obviously another important reason – 70 percent of the total energy produced in Denmark stems from petroleum).[4] And in two decades, Denmark has gone from having a centralized electricity network based on fossil fuels to one where wind power features very prominently. The *Energy Strategy 2050* plan envisages a grand future for renewables, in which wind power will account for 50 percent of electricity demand already by 2020, and renewables for 100 percent of all electricity by 2050 (DEA, 2012; Lund et al., 2013; Sovacool, 2013).

Not having an energy champion of its own, Denmark not only sought to satisfy its energy needs by other means, but built a home-grown industry in the process. Danish wind in 2013 employed 27,500 people and constituted an industry with a turnover of €11 billion (in comparison, Norwegian wind employs 200–300 people, and has a turnover of €25–40 million) (Buen, 2006; Damvad, 2014; *Vindmølleindustrien*, 2013).[5] Vestas has dominated the European market, and has for most of the millennium been the dominant player worldwide, typically with market shares above 15 percent. (It was temporarily displaced by US company GE Wind in 2012, but only because the US market had a particularly good year.) In solar PV, China now controls the world market, but within wind, technologies have not been so widely dispersed and commonplace as in solar, and so in this area Chinese companies have provided far less competition beyond the Chinese market itself. In the early years of the industry, industrial success very much depended on a large home market. And while the Danish home market was for long one of the largest in the world, Denmark is a small country. Thus, Vestas now exports 97.5 percent of its production and has made wind turbines into a major Danish export industry. However, as home markets developed elsewhere, Vestas inevitably also lost part of the first-mover advantage that it, with the rest of the Danish wind power industry, once had. Ten years ago Vestas had 35 percent of the world market. Today it is down to 13 percent, and the company has had to go through a painful restructuring, including management change, cost-cuts, outsourcing of production processes, and major layoffs (including cutting 30 percent of the staff). Despite this, Vestas remains one of the biggest wind power players in the world. It should also be noted that several of Vestas' European rivals had their beginnings in Denmark. The German company Siemens Wind, which is another one of the world's five largest manufacturers, and which has cornered the European offshore market, started life in Denmark as Danregn, then changed its name to Bonus, and was acquired by Siemens in 2004. Nordex, another German top ten manufacturer, also has Danish origins. Danish electric utility company DONG Energy is the world's largest offshore wind operator and Denmark's largest utility. Danish companies have installed more than 90 percent of the world's offshore wind mills, even if Siemens is now outselling Vestas. Thus, Denmark is strong, not to say dominant, in a number of areas (denmark.dk, 2014; *Economist*, 2014b; Lewis and Wiser, 2007; REN21, 2014; *Reuters*, 2014c; Wieczorek et al., 2013).

Danish wind benefits from strong path-dependencies. Its history can be traced back at least to 1891, when Paul la Cour received parliament support to build a windmill for electricity generation. By the time he died in 1908, 30 electricity works (partially) driven by wind power had already been erected. In the 1950s, Johannes Juul headed a new wave of developments, culminating in 1957 with the truly pioneering, and for many years the world's largest, 200 kW Gedser wind turbine (Jensen, 2003; Krohn, 2002). Only between 1967 and 1976 has wind power not delivered electricity to the Danish grid. With the 1970s rise of the modern 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. The government introduced its first energy plan in 1976, where wind power was presented as one of the alternatives to nuclear power (which was however not finally rejected by parliament until 1985), and energy taxes on electricity were used to support R&D for renewable energy. Denmark pioneered both the investment subsidy – introduced in 1979 and initially covering 30 percent of the expense of renewable energy systems – and in 1981 a system by which the electric utilities were required to buy all power produced by renewable energy. One crucial part of the Danish system was provided by the Danish Energy Agency in 1985, when renewables was guaranteed open access to the grid. The utilities paid for the costs of reinforcing the grid, while the wind turbine owner had to pay for the low voltage transformers and the connection to the nearest connection point (Sovacool, 2011, 2013). Priority access to the grid, meaning that the utilities are obliged to purchase electricity produced by renewables, has been very important, not just in Denmark, but in Germany and in China too, whereas it has been sorely missed in Norway and only recently been introduced in Japan. Yet another vital piece in the Danish renewable jigsaw puzzle was a FIT, which was introduced in 1993 (Denmark being the second country to do so, only behind Germany), as part of the Third Energy Plan. The Third (1990) and Fourth (1996) Energy Plans both made concrete targets for future installations. In the former, 10 percent of the electricity consumption would be supplied by wind energy by 2005 (the actual figure turned out to be almost 19 percent), in the latter 12–14 percent of total energy consumption would be renewable by 2005, and 35 percent by 2030. A dedicated agency – the Danish Energy Agency (established in 1976) – was given the responsibility to implement renewable energy policy (IRENA-GWEC, 2012; *Energinet.dk*, 2015).

Denmark also had some good luck. With the California Wind Rush came the world's first major commercial market. From 1982 onwards, Denmark supplied the majority of foreign wind turbines that were installed in California, and the quality of the Danish turbines meant that they were highly competitive. However, the end of the California program in 1986 also led to a near wipeout of the Danish industry, as their biggest market suddenly disappeared. Granted, the Ministry of Energy and the utilities had reached an agreement in 1985 that between 1986 and 1990 Denmark would install 100MW of wind power domestically, making up for some of the loss of the California market, but the entire industry had to restructure, and only a few narrowly survived.

These – Vestas, Nordtank, Micon, and Bonus – did, however, go on to become the core of Danish wind power (IRENA-GWEC, 2012; Jensen, 2003; Krohn, 2002; Vestergaard et al., 2004).

Despite a regulatory framework that has for the most part been stable and beneficial, Denmark has also had its ups and downs. In line with EU recommendations and domestic cost-effectiveness concerns, in 1999 the FIT was abandoned and an RPS system with tradable green certificates agreed on instead, due to start in 2003. The certificate plans were abandoned in 2002, but the support level for wind power reduced to a lowly DKK0.10 (€0.013)/kWh. Also, in 2001 R&D funding was cut by more than 80 percent, the argument being that the state should not subsidize a thriving industry (Energistyrelsen, 2004). After all, wind power support has come at a price. Estimates from the IEA (2006) show that in the 1990s, with CO_2 emissions valued at DKK270 (€36) per ton, 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 this the cost of subsidies and preferable taxation came to DKK25 billion. The environmental benefits amount to DKK20 billion, with another DKK2 billion accruing from the growth of a healthy windmill industry (IEA, 2006). However, the result of cutting R&D funding and introducing an RPS was a more or less complete halt to Danish wind power expansion. Granted, the value of wind power *exports* kept soaring, quadrupling since 2000 (*Vindmølleindustrien*, 2011). But between 2003 and 2008 only 47MW of wind power was installed (as opposed to 847MW between 2001 and 2003),[6] and in 2007 net growth was actually negative, as more old installations were phased out than new ones were built. The wind industry argued hard 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 2005 saw policies again start swinging back in the favor of wind, and a 2008 grand political bargain increased wind power support back from DKK0.10 to a more reasonable 0.25/kWh (€0.013–0.033/kWh).[7] Offshore FITs are awarded according to a tendering system, yielding subsidies in the €0.06/kWh range. It also set a target of increasing the use of renewable energy to 20 percent of gross energy consumption by 2011 (Ernst and Young, 2012b; IEA, 2011a; *Information*, 2008a; IRENA-GWEC, 2012; Megawatt, 2008; *theenergycollective*, 2013a).

The new system has led to renewed domestic growth, up from 3.1GW of installed capacity in 2008 to 4.8GW in 2014. From the current capacity, another 2GW is expected by 2020, and implementing the goals from the *Energy Strategy 2050*, the renewable share of total energy supply should reach 33 percent already by 2020 (the renewable share of *electricity* demand is already beyond this, at 39 percent). But it has also given a renewed boost to offshore wind. Over the past decade, growth has been particularly rapid offshore, and offshore wind will most likely see around 60 percent of the new installed capacity up until 2025 (GWEC, 2014, 2015; IEA, 2011a). At almost 1.3GW of capacity, Denmark is behind Britain only in terms of offshore wind installations, and given the precariousness of Danish land space, it is not surprising that this is where most of the future capacity growth will happen.

However, the support system goes beyond wind power. Unlike Norway, Denmark never had a solar industry, but it is described by EPIA (2013, p.19) as 'the major surprise of 2012 thanks to a net-metering system'. Thus, Denmark currently holds a PV capacity of 548MW, most of which was installed in 2012 and 2013 and accounting for a little over 1 percent of Danish electricity demand. This is obviously not much compared to, for instance, Japan, but Danish support policies are recent and show how rapidly it is possible to phase-in solar even in a small country with quite severe climatic constraints. The FIT amounts to DKK0.60/kWh (€0.08)[8] whereas residential PV units below 6kW are instead exempt from energy taxes and part of a net-metering program, whereby customers can effectively run the electricity meter in reverse, corresponding to what during the introduction of the program amounted to a FIT of an enormous DKK200/kWh (€27). The net-metering system has since been altered, severely reducing the attractiveness of the program. Even so, 2013 saw more than 200MW of installations, although down by about a third from 2012 (EPIA, 2013, 2014a; IEA, 2011a; REN21, 2013a; Sovacool, 2013).

The expansion in Danish wind will quite likely put a strain on the existing grid network. While Denmark is a small and highly developed country and thus not facing the same kinds of infrastructural challenges as, for instance, China, the country is still divided into two separate grid networks and also needs stronger interconnectors to other countries. Denmark has relatively strong connections through transmission lines to Germany, Sweden, and Norway. But if it wants to reach its 2050 goal of a fossil-free energy system, more cross-border interconnectors are absolutely necessary since intermittency problems will only increase as more renewable energy is phased in. In this area, growth has been too slow and interconnections have been delayed. The problem is similar to in Norway, namely that there are few economic incentives for the market to invest in interconnectors. More interconnectors to Norway, so as to benefit from Norwegian hydropower, would, however, be quite useful (Ernst and Young, 2012a, 2013a; Jacobsen and Zvingilaite, 2010).[9] Ernst and Young (2013a) actually warns that Denmark might lose its first-mover advantage and fall behind Europe if action is not taken in this area.

A vested interest structure biased *toward* wind power?

Vested interest structures biased against renewable energy is a theme that recurs throughout this book. Sometimes they are there for everyone to see, as in Norway and in Japan, while on other occasions they are better hidden, as in China where the support framework and government institutions are highly pro-renewable, but where vested interests lurch very heavily in the shadows once you move out of Beijing and into the provinces. Denmark, however, is a country where it makes sense to think of a vested interest structure biased *toward* wind power rather than against it.

The Danish structure differs profoundly, for instance, from the Norwegian, not only in the sense that wind power has found itself on the inside of the structure almost from day one (with some notable exceptions), but also in the sense that in Denmark wind power has become so influential and such a prevalent part of the energy system that it is now itself one of the dominant vested interests of the system. It is supported by the institutional framework. It is not unaffected by political swings, but has such a big industrial and energy political footprint that despite political swings, it will always be an actor with excellent access to political and bureaucratic channels. Thus, also during periods of political and industrial gloom, wind power is an industry that in Denmark will sooner or later once again regain political favor. It has a status that is stronger than pretty much anywhere else, and wind power has become part both of the Danish cultural landscape and industrial identity.

Granted, of the countries discussed in this book, Denmark is also the one in which we should expect the most ambitious renewable energy policies simply by virtue of its energy-security situation (highly energy-secure today, but very much not so in the 1970s and 1980s when the foundations for the modern Danish wind industry were laid) and its renewable energy potential. This, however, is no complete explanation for the Danish effort. There are other countries that are not so different in terms of size, energy security, and climatic conditions, but Denmark was by far the one that went the farthest – and the fastest – in the direction of renewable energy. Research endowments alone cannot explain the Danish path.

Thus, there are a number of ways in which the Danish vested interest structure is entirely different from those of the other countries. The first obvious way in which it is tilted toward wind is in path-dependencies going back at least to the 1891 la Cour windmill, and the knowledge advantages that this brought. Danish wind was ahead of the world with the 1957 Gedser wind turbine, and technology and quality meant that Denmark was uniquely positioned to take advantage of the California Wind Rush in the 1980s. Path-dependencies have pushed Denmark in the direction of wind and consistently upheld the Danish advantage.

One of the areas in which the role of the state in supporting wind power can be seen most clearly was in the 1978 establishment of the Risø Test Station (originally founded in 1958 as the Risø Nuclear Research Centre, but now in dire need for new tasks to take on as Denmark was becoming ever more skeptical toward nuclear power), which rapidly developed into one of the most important wind power research hubs in the world (Buen, 2006; Megavind, 2007). The initial purpose was to help wind turbine producers onto the market, but its main role soon became one of establishing standards that Danish producers had to live up to for turbines to be certified. This required considerable knowledge- and information-sharing between wind turbine producers and the test station, but it also forced dramatic quality improvements of Danish turbines, which gave Danish manufacturers significant advantages abroad (Krohn, 2002; Vestergaard et al., 2004).[10]

Risø has grown a number of public research programs and works tightly with the industry. To this day, Denmark represents 'a unique hub of skilled laborers and an experienced network of key components suppliers to support turbine manufacturers' (Lewis and Wiser, 2007) and the critical mass of technology, industrial resources, and research is world class. There are countries that have allocated more money to R&D for wind turbine development. Yet, the Danish effort has been highly successful, studies suggesting that Danish R&D has been allocated more efficiently among smaller companies, with a greater variety of turbines and technical solutions. The Danish approach has been bottom-up, gradually building on already existing comparative advantages rather than top-down, as chosen by several other countries. Notably, the one serious top-down attempt (1981–89) at creating a national champion, Danish Wind Technology, owned one-third by the state, was a failure and was eventually taken over by Vestas. In this sense, Danish wind power has to a far lesser extent than in most other countries had to fight against existing industrial structures, and found it fairly easy to get on the inside, somewhat similar to solar PV in Japan. A fortunate human capital advantage also stemmed from the rise of wind power coinciding with the fall of several agricultural companies. These then utilized their knowledge in machine production to diversify into wind turbines, using their supplier networks and capital base to become the cornerstone of Danish wind. In addition to Risø, Denmark also has the Offshore Centre Denmark, which has as its primary role to bring incumbents and start-ups within offshore wind together (Buen, 2006; Jensen, 2003; Lewis and Wiser, 2007; Megavind, 2007; Vestergaard et al., 2004; Wieczorek et al., 2013).

Concerns have been raised that the human capital lead is evaporating and that Denmark is not doing enough. Danish wind is in constant need of new graduates, and the country may face a generation gap when the current crop of engineers retires, as there are simply not enough skilled experts with practical experience to fill their shoes. Also, the past few years have seen a system shift in wind, as in the scaling up in terms of size and mass production and the growth of wind power giants and markets outside of Denmark. The industry has turned very global quite rapidly. This has by all means not bypassed Denmark. The average turbine size is actually greater in Denmark than anywhere else (3.1MW as of 2012 (REN21, 2013a)). Still, the emphasis on networks and cooperation – on learning by doing and on constant feedback from inventors and entrepreneurs, which was so crucial and so characteristic of the early phase of the Danish wind industry – is no longer the same, and the relationship between academic R&D and the industry is not as close as it used to be. The pace of development is currently so fast that academic research has difficulties keeping up (Andersen and Drejer, 2006; Megavind, 2010; Sovacool, 2011; Vestergaard et al., 2004; Wieczorek et al., 2013). Andersen and Drejer (2011) states that while Denmark is no longer the dominant wind power actor that it used to be, it is still doing well in terms of human capital, research funding, links, and networks. Risø, for instance, publishes more scientific articles on offshore wind power than any other European institution (Wieczorek et al., 2013). However, foreign companies have been better at utilizing Danish knowledge than Danish companies, and the knowledge advantage can no longer be taken for granted. If the industry does not develop and adapt, the smaller Danish actors, like different subcontractors, will lose out to foreign competition. But even a giant such as Vestas is being challenged. Part of the reason why GE now rivals Vestas worldwide and Siemens does in Europe is that these are conglomerates that can offer transmission, storage, and other capacities, whereas Vestas does only generation (*Economist*, 2014b).

Irrespective of this, for decades, Denmark has had a human capital advantage, stemming from both path-dependencies and government initiatives to promote R&D and to build Denmark as a wind power knowledge hub. This advantage certainly is important in explaining why Danish wind has consistently been on the inside of the system.

In Norway, the institutional structure is geared toward the needs of petroleum. In Japan, the utility companies have had easy access to politicians and (more importantly) bureaucrats. In China, the institutional structure leaves a lot of the implementation to the provincial governments. Denmark, in contrast, has an institutional structure that has been quite conducive to growth in renewables for several decades already.

The Ministry of Energy has been coordinating wind power ever since 1980, with long-term planning initiatives launched in both 1990 and 1996. All three initiatives named specific goals with respect to the share of electricity produced by wind (Buen, 2006). Throughout the 1990s promoting renewables was a primary energy objective. More recently, 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, then Prime Minister Anders Fogh Rasmussen presented a long-term target of 100 percent independence of fossil fuels and nuclear, which then became the Energy Plan of 2006. Flowing from this was the Danish Association of Engineers Energy Plan, which contained goals of renewable energy accounting for 30 percent of national energy supply by 2025 and 100 percent by 2050, in addition to introducing 500MW of wave power and 700MW of solar power. Then, in 2010, the Energy Concept 2050 was presented, including a series of steps and measures to be taken, some of which are already being implemented. Once again it introduced the goal of a fossil-free energy system (by 2050), and it specifies an increase in wind power production from roughly 25 to 50 percent of electricity demand. Most recently, the 2014 climate law commits Denmark to reducing its climate gas emissions by 40 percent by 2020 and reiterates the 2050 fossil fuel-free energy goal (*BT*, 2014; Lund et al., 2013; Sovacool, 2013). A study by Lund and Mathiesen (2009) concludes that 100 percent renewable energy supply based on domestic resources actually *is* physically feasible in Denmark. This does, however, mean integrating enough intermittent resources of energy (in other words renewables) into the system for this goal to be achieved – which will require major upgrades to the grid system – as well as electrifying the transport sector.

The history of Danish departmental reshuffles does, however, make it evident that renewable energy and climate concerns have not always fitted well into sectoral departments. From 1973 to 1994, the Ministry of Environment had close connections with the Ministry of Energy, which in 1994 became the Ministry of Environment *and* Energy. This reflected the fact that after the 1970s oil crises, energy policy to a great extent was synonymous with environmental policy. This lasted until 2001, when energy policy was moved to the Ministry of Economics and Industry, reflecting a policy change *away* from renewables and toward 'old industry'. This lasted until 2005, when energy was put under the Ministry of Transport and Energy, and from 2007 moved to the new Ministry of Climate and Energy, absorbing issue areas formerly belonging to the Ministry of Environment and the Ministry of Transport and Energy, including the responsibility for energy legislation. This symbolized that wind power was now again back in favor with the state, being perceived as a crucial part of Danish climate strategies. 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 with climate policy, and is a policy change that favors renewables.

Until 2001, the institutional structure was geared quite strongly toward the needs of wind power. Wind power was clearly taken seriously, and institutions shaped so as to cater to the needs of the industry. However, portraying Danish renewable energy policy as something akin to Japanese MITI-like planning and oversight on the part of the state is well wide of the mark. Denmark was not deliberately targeting any specific industries as prospective growth industries of the future, or fostering national champions. Instead, many of the policy initiatives came from *reacting* to economic and technological developments and to opportunities abroad, rather than from actively trying to shape developments. But when policymakers have reacted, they have typically done so in a way that has been favorable to wind (Jensen, 2003; Vestergaard et al., 2004). As much as they benefited from favorable conditions from the state, with respect to the deliberate building of human capital, to good investment conditions, and a beneficial institutional framework, it should not be forgotten that the rise of the modern Danish wind turbine industry came from private, independent entrepreneurs. While the state was involved as early as with la Cour, the rise of the modern industry was driven by innovative and charismatic entrepreneurs with a strong belief in the future prospects of the industry. Only after they had taken the lead and done the early running did politicians start taking an interest, both as an answer to the oil and energy crisis and as an alternative to nuclear power (Jensen, 2003).

Thus, once the initial phase, characterized more by private entrepreneurial initiatives than governmental planning, was over, wind power was singled out by the state, buoyed by the coordinated lobbying of the Danish Wind Turbine Owners' Association, the Danish Wind Turbine Manufacturers' Association, and by public support, and stimulated by research facilities. Again, not overstating the degree of planning on the part of the state, a number of policies and measures were then adopted by the state in order to create an increased supply of energy and a strong and independent domestic industry. While these have not remained constant, leading to certain notable stops and starts in wind turbine installation, the commitment to wind power has persisted for 25 years and provided the Danish industry with better opportunities than in most other countries (Buen, 2006; IEA, 2006; Jensen, 2003; Krohn, 2002; Sovacool, 2013).

The changes to the institutional structure have reflected deliberate changes in policy. In particular the 2001 change, when energy policy was moved to economics and industry, was a result of a major political swing. In Norway, cost effectiveness has long been one of the pillars of energy policy. In Denmark, this was not equally so. The original drive for wind power came from energy-security concerns, hence the onus was on energy production and the build-up of a wind power industry, even if this might be expensive. Granted, compared to most other countries, Danish wind power schemes have been relatively cost-effective, stimulating technological improvement and efficient electricity production. They have stimulated both demand and supply. Early policies stimulated demand through demand-side subsidies to cooperatives and private wind turbine buyers. This provided a context for wind power characterized by decentralized bottom-up, relying on existing competencies, and where demand from private and cooperative developers created a steady and secure home market. The creation of a viable domestic market, populated by domestic companies Vestas and Bonus (later Siemens) that have covered 99 percent of the market, has been one of the greatest triumphs of the Danish state (Buen, 2006; IEA, 2006; Jensen, 2003; Lewis and Wiser, 2007; Nielsen, 2002). Although these days the Danish home market is not particularly big compared to that of other countries, it did provide the industry with a very solid footing at a time when it was still young and vulnerable.

However, with the 2001 change in government, the more market-oriented Danish administration of Fogh Rasmussen sought to streamline energy policy along cost-effectiveness lines, not completely unlike what Norway had done, and wanted to scrap the FIT in favor of an RPS. Energy policy would no longer be thought of in terms of environmental or climate policy. Instead, he wanted to rein in what he perceived of as an ever more influential Ministry of the Environment. Thus, Denmark in its climate policies took a leaf out of Norway's book, by insisting that Kyoto commitments would now be met more explicitly through emissions reductions abroad, again for cost-effectiveness reasons. For a wealthy, industrialized country, funding emissions reductions abroad is clearly cheaper and more cost-effective than implementing reductions at home, and from 2001 onward both climate and energy policy would to a far greater extent be subject to the laws of the market. Thus, if wind power could compete on price alone, it would triumph, and if not, the Danish government would not subsidize what is after all one of the biggest Danish export industries. As mentioned earlier, this even led to negative net installation of wind power capacity in 2007 and to one of the least-generous support systems in Europe.

Thus, what this chapter is not trying to argue is that Danish wind power is powerful enough to get its way no matter what. It is an industry that relies on subsidies, even if it is closer to being cost-effective than most. And, as such, it will always be vulnerable to political swings. But Denmark does have two quite strong wind organizations and, established decades ago, they have had time to coordinate. They are also not marginalized by industrial or institutional structures, and so their effect on policy has been considerable. Granted, a petroleum industry eventually rose, and its influence should not be discarded, but by then wind power interests were already strong and able to draw upon major support groups in the parliament. Thus, when the government made energy and climate policy more market-based, this met with massive resistance and pressure from the wind power industry – among other things arguing hard that part of Denmark's climate commitment should be met through wind power. And in this, wind power had allies not just in the opposition parties, but in the Association of Small- and Medium-sized Enterprises, and from a number of large industrial corporations where several CEOs openly denounced the new energy policies as reactionary. Thus, already in 2005, the Fogh Rasmussen administration was starting to shift its emphasis back toward wind. This happened for several reasons. There was the quite obvious concern that one of the most important Danish industries might suffer. There were also energy-security concerns – President George W. Bush had recently proclaimed that the US was addicted to oil and was very interested in learning about Danish wind, and in Britain and Germany heads of government Tony Blair and Angela Merkel worried about where the energy of tomorrow would come from (beyond less than democratic sources such as the Middle East and Russia) in a world with soaring Chinese energy demand and rising oil prices. They all influenced the Danish government, in providing an image of a future where energy would become ever more precarious. And most likely what was also important was the personal influence of new Environmental Minister Connie Hedegaard, who very actively sought to put climate change and renewable energy back on the political agenda (*Information*, 2002; *Politiken*, 2007).

The policy swing back toward renewable energy eventually led to a cross-political consensus on a more ambitious renewable policy course. This was reinforced in 2008 with the grand political energy bargain and with two political documents marking a new renewable energy course more along the lines of pre-2001 policies, aiming to reduce the dependency on fossil fuels and increasing wind power's share of overall energy production. The bargain stressed that Denmark still was committed to addressing climate change at minimal economic costs and without risking security of energy supply, with energy-efficiency an explicit priority. Thus, the rhetoric of cost effectiveness was retained. However, renewable energy was also back on the agenda, with wind power support from 2009 onward essentially restored to pre-2001 levels. It culminated with the drafting of a Renewable Energy Act, whereby all renewable energy legislation would be gathered in one legal document, and in the process changing both the financial incentives and local implementation (Buen, 2006; Eikeland and Sæverud, 2007; *Information*, 2008b; IRENA-GWEC, 2012; Sperling et al., 2010).[11] What is noteworthy about the entire process is the extent to which interest groups and political actors dragged Danish energy policy back toward renewables. If anything, Danish vested interests are interests favoring wind, not opposing it. Sovacool (2013, p.838) gives the renewable energy lobby much credit for the post-2008 changes. Since then, government renewable energy targets have typically been criticized for not being progressive enough rather than the other way around.

As we keep looking for differences between the Danish vested interest structure and those of other countries, public opinion is another obvious area where Denmark stands out. A number of studies suggest that regional opposition against wind farms is widespread throughout Europe, and the evidence from the Norwegian case suggests that local opposition can be a powerful brake on wind power. Facilitating local ownership and institutionalizing local participation in planning seem to be key to social acceptance. Among other things it seems important to create systems that enable the local community to benefit directly in financial terms from the erection of the wind park (e.g. Breukers and Wolsink, 2007; Jobert et al., 2007; Nadaï, 2007, Wüstenhagen et al., 2007).

This has largely been achieved, and so, in comparison to the other countries in this book, what is striking is how in Denmark wind power has been both local and popular. The Danish vested interest structure does not hold any strong popular anti-renewable sentiment. Turbines are perceived as an integral part of the cultural landscape, partly because Danish wind power always was a grass-roots phenomenon, stemming among other things from the general resistance against nuclear power. And, more recently, environmental concerns have given local support additional boosts (Jensen, 2003; Nielsen, 2002; Vestergaard et al., 2004). A study carried out by the Danish Energy Agency in 2006 showed almost 85 percent support for wind power being used 'to a great extent' (Energistyrelsen, 2006). The comparison with Norway is telling. Here, wind turbines have typically been located with power supply and cost effectiveness in mind, resulting in Norwegian wind farms often being erected in highly scenic locations, rather than in less-exposed locations that would, however, be costlier and less-visually intrusive. But in Denmark, already in 1992, more systematic planning procedures were developed, whereby Danish wind power developers had to put more emphasis on visualization, and where they explicitly had to minimize the impact on the landscape. Siting problems arising out of public protest has been par for the course in so many other countries, but in Denmark these have been minor problems only (Jensen, 2003; Nielsen, 2002; Sperling et al., 2010; Wüstenhagen et al., 2007).

Further, in addition to being an accepted part of the cultural landscape, 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 being direct economic beneficiaries.[12] For smaller installations, concessions are left to the local municipalities, provided that technical requirements are fulfilled.[13] This means that the process is highly decentralized and relatively fast. Ownership is decentralized, with cooperatives of a few hundred investors typically owning three to five turbines. The RPS scheme may have contributed to pushing community wind power into decline, but the 2008 grand political bargain is meant to facilitate a greater degree of local participation and less-centralized bureaucracy, making implementation less top-down as well as increasing the fiscal benefits for the municipalities. For instance, there is now both a guarantee fund for wind cooperatives and a compensation scheme where the project developer will compensate property owners for any loss in real property value caused by wind power installations (Buen, 2006; *Information*, 2008a; Megawatt, 2008; Nielsen, 2002; Sperling et al., 2010). However, as technologies improve there is an obvious tendency toward ever larger installations. Current wind turbines are five to ten times as expensive as the wind turbines of only a decade ago. Thus, these are projects that cannot as easily be undertaken by local communities. Today, most wind turbines are owned either by individuals or by utilities. Thus, ownership has become more concentrated and to an ever greater extent removed wind power from its local origins. Beyond the size and investment costs of new turbines, this development was also made possible by legislative changes no longer obligating wind turbine shareholders to have their residence in near proximity to the turbines. Subsequently, there has been increasing local resistance as cooperatives and farmers are being excluded from ownership and participation. Also, the tendency toward ever larger installations has met with resistance. Hence, a strategy of late has been to install bigger wind mills and wind parks at sea, away from the public eye, also benefiting from stronger wind than onshore (Sovacool, 2013; Sperling et al., 2010; *theenergycollective*, 2013a).[14]

Overall, despite ups and downs, policy has been beneficial to the deployment of wind power in Denmark. Denmark has in general not been hampered by a vested interest structure that has conspired against structural change. Denmark introduced a carbon tax as early as the 1990s (however, Norway did too, so it is clearly possible to maintain both a carbon tax and an economy heavily based on petroleum revenues at the same time). It introduced investment subsidies and FITs early on. But in addition to all this, Denmark provided wind power with guaranteed access to the electric grid, which has been a crucial prerequisite. It prevented electric utilities from blocking renewable energy, which it has routinely done in many other countries, blaming their reluctance to integrate renewable power on high costs, and on inadequate transmission and distribution networks. Thus, no major vested interests have been able to block the rise of wind power. Rather, whatever swings have existed in the fortunes of Danish wind have largely coincided with political swings, and these have been temporary.

Conclusions

Denmark serves as evidence of the extent to which structural change in the energy system can be achieved without this having major negative economic consequences. In the process, Denmark has also become one of the most energy-secure countries in the world, even if this is admittedly in large part due to Denmark also becoming a petroleum producer. 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 have meant that Danish wind is no longer a new and vulnerable industry. Granted, subsidies are still necessary. As in other countries, wind power has still not matured to the extent that support can be relinquished. But this is also one of Denmark's top export industries, and so, Danish success is not only about installations at home, but is as much about exports. Despite certain notable ups and downs in terms of policy support, compared to most countries, Danish energy policy has enjoyed considerable consensus. It has provided the industry with long-term planning scenarios and a solid base for decisionmaking. Hence, when Danish entrepreneurs made their forays into wind, 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 quickly ended up on the inside of the institutional structure. No major structures had to be torn down in order to pave the way for it, but new structures have been built and institutions created to suit its needs. This explains why structural change in the Danish energy sector has come about easier than in most other places. The swing away from renewable energy policies in 2001 is really a case in point. Once policy shifted away from wind, it put in motion forces that within a few years essentially restored something akin to an equilibrium in Danish energy policy. And this is where Denmark has been different from the other countries in this book (with the partial exception of Germany): Denmark has an energy political equilibrium where wind power is at the hub rather than trying to replace the actors that are already there. No country comes closer to having wind power as a vested interest.

At the same time, while Denmark is an undoubted 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, and without foregoing goals of continued economic growth, the achievement should not be exaggerated, and Denmark should not be praised beyond what it deserves. Ernst and Young (2013d) lists Denmark behind the US, Germany, and China in its renewable energy index, with respect to renewables in general as well as with onshore and offshore wind. Thus, despite ambitious policies, a full recovery from the years between 2001 and 2008 has yet to be achieved.[15] While the country has some of the most ambitious long-term goals both in terms of renewable energy production and in terms of producing a fossil fuel-free energy system within 2050, as well as taking concrete steps toward fulfilling these goals, Denmark still has one of the largest CO_2 footprints on the planet – a planet of Denmarks really would not be sustainable! And while not one of the largest petroleum producers in the world, if we look at the Danish total primary energy supply, conspicuously, 75 percent still comes from fossil fuels (37 percent from oil, 20 percent from natural gas, and 18 percent from coal) (IEA, 2011c). Denmark produces 13TWh of electricity a year. By most standards, this is highly impressive. However, if we compare this to electricity from Norwegian hydropower, which fluctuates between 110 and 140TWh a year, we are left with renewables frontrunner Denmark actually only producing one-tenth of the renewable electricity that laggard Norway does! And so, Danish success needs to be put in perspective.

Also, success is never won once and for all. There is no guarantee against future political swings that go against the interests of wind power. Even if for now the chance seems remote, fulfilling the very ambitious goals of the *Energy Strategy 2050* will most certainly have to lead to sacrifices that will be met with resistance, and most likely with cost-effectiveness arguments. And if we take the view of Vestas and the rest of the Danish wind power industry, global wind power has become a rapidly changing big business. Denmark constantly needs to develop and adapt in order to stay competitive. While a major success until now, success can never be taken for granted. Still, in terms of structural change, of the six countries discussed in this book, Denmark has been by far the biggest success at this stage, with wind power solidly on the inside of the industrial system and the institutional structure, and with a thriving export industry to boot.

7

Norway: A Petro-Industrial Complex Leaving Little Room for Structural Change?

Introduction

Norway is kind of the odd country out in this book and the least likely candidate for an energy transformation. It has a reputation and a self-image as a clean and environmentally conscious nation, with large swathes of pristine and untouched nature. However, it is also the world's third largest exporter of energy (behind Russia and Saudi Arabia) (IEA, 2011b), energy for all practical purposes meaning oil and gas (and some hydro). It is also in the quite unique position that its hydrocarbons are mostly exported, since they are not needed for electricity: 96–98 percent of all electricity is instead produced by hydropower (OECD, 2011). Thus, Norway is one of the most energy secure and self-sufficient countries on the planet, exporting almost eight times more energy than it consumes (Godzimirski, 2014). This also means that apart from the self-image of being uniquely clean and pristine, and the programmatic statements of any Norwegian government that the country enjoys frontrunner status in all things environmental, for all practical purposes, despite vast renewable energy resources, Norway has had little incentive to invest heavily in renewable energy beyond hydropower.

Instead, as one of the wealthiest countries on the planet, Norwegian affluence – beyond being a well-organized country with well-functioning markets, reasonable economic policies and decent institutions – rests heavily on a petroleum sector that accounts for 26 percent of annual investments, 22 percent of GDP, and 47 percent of Norwegian exports, and where the petroleum company Statoil, owned 67 percent by the state and on its own generating 9 percent of Norwegian GDP and 18 percent of export revenues, is by far the country's biggest. The state's petroleum revenues amount to almost $50 billion a year (NOK280 billion),[1] and between 1977 and 2011, petroleum exports generated revenues of well above $1000 billion (NOK6490 billion) (Fermann, 2014; Godzimirski, 2014). Norway consciously and meticulously built a domestic petroleum sector to fully exploit its North Sea riches, which has led to the petroleum sector being the most prosperous of all Norwegian industries and arguably the strongest vested interest, with an institutional and bureaucratic apparatus built to cater to its needs. Granted, the Norwegian petroleum sector is also one of the most heavily regulated in the world, but there is very little doubt that this is a sector that wields a lot of influence when it comes to Norwegian political-economic decisionmaking.

What we might then expect is a country where despite strong environmental pretensions, energy policy is still heavily tilted toward prolonging the extraction of petroleum into an indefinite future, and with a vested interest structure biased toward satisfying the requirements of petroleum, and to the extent that it caters to renewables, to hydropower rather than wind and solar. This is a situation from which little structural change can be expected. No Norwegian energy transition is underway and the discourse on energy is premised upon petroleum remaining the mainstay of Norwegian prosperity. Thus, one of the missions of this chapter is to say something about the extent to which petroleum is so entrenched in the Norwegian vested interest structure that any major change for all practical purposes is being pushed into a distant future.

While Norwegian wind power has enjoyed a moderate upswing as of late (solar PV is virtually non-existent), renewable efforts beyond hydropower have been feeble. At 856MW of installed capacity (2014), Norway lags far beyond most other countries, despite having a wind power *potential* that exceeds most. While the prospects for Norwegian wind power have improved, it is not obvious that growth will persist, or that the support framework will favor wind rather than more hydropower. Early, and what seemed like highly promising, forays into offshore wind have also run into major political hurdles.

This chapter argues that in Norway, there has been little willingness to challenge the interests of the petroleum sector, and very little interest in undertaking any kind of energy transition. Norwegian energy policy has not experienced any Schumpeterian moment (apart from in the early 1970s, when the Norwegian petroleum sector was conceived). Instead, growth in renewables has had to come in addition to, and not at the expense of, petroleum. Despite recurring fears on the part of politicians and economists that the petroleum sector crowds out growth in other industries and pushes structural change into an unknown future, there is little to suggest that major energy political change is near. Wind power will remain a bit-part player even if it is now growing reasonably briskly. Arguments have been made that Norway, with its hydropower resources, could and should become a green battery for Europe (Gullberg, 2013). However, in the absence of sufficient transmission capacity to the Continent, a coordinated strategy between a number of countries, among other things involving a substantial and expensive upgrading of the Norwegian grid network, would be necessary. At present, this seems to belong more to the realm of speeches and lofty rhetoric than to political reality. It is an idea that holds much promise, but politics and economics are not aligned in such a way as to make this realistic in the foreseeable future.

Old renewables

In one sense it seems very unfair to criticize Norway for its lukewarm renewable energy policies. After all, Norway is one of the countries with the highest share of renewables in its energy production in the world. Approximately 96–98 percent of the electricity consumption derives from hydropower, something that is unprecedented among anything but Lilliputian countries, and at 40–50 percent, the share of renewable energy in the Norwegian total primary energy supply is also highly impressive (IEA, 2011b; OECD, 2011).

Thus, the first reason why new renewables in Norway has mostly been treated as an afterthought is that Norway did not have much need for other types of renewables in the first place and already had a vested energy interest in hydropower. Early Norwegian industrialization, from the beginning of the 20th century onward, was to a major extent founded on the exploitation of waterfalls for hydroelectric power. Thus, by the 1960s, between a third and a half of all Norwegian waterways had been regulated (Jansen and Mydske, 1998). The 1950s and 1960s saw the rise of a hydro-industrial complex, resulting from the state's strong political priority of abundant electricity at reasonable prices, both for regular households and for Norway's important power-intensive industrial sectors. This could only be done by going extensively against the market and systematically over-investing in electricity production. And, despite the fact that the political goals were eventually fulfilled, the sector kept expanding, accompanied by cost overruns and weak oversight from close ties between government institutions, hydropower, and energy-intensive industry (Christiansen, 2002; Midttun, 1988). Thus, preceding the emergence of a petro-industrial complex, Norway already had strong vested energy interests. Because some years have more rainfall than others, there are considerable fluctuations in electricity production from hydropower, but in a normal year, Norwegian hydropower yields approximately 120–130TWh (*Energilink*, 2013),[2] which is almost as much as Chinese electricity production from wind power, and in a good year ten times more than Denmark generates from wind. At a record 143TWh in 2012, Norway was the sixth largest hydropower electricity provider in the world, and in regular years, with normal rainfall and normal reservoir levels, Norway is a net exporter of electricity (REN21, 2013a).

However, the last major dam project was finished in the 1980s and accompanied by major controversy and indigenous protest. So, when Prime Minister Jens Stoltenberg in 2001 stated that the time for major hydropower developments had passed, this was both because of the built-up controversy surrounding every major new regulated waterway and because after a century of hydropower expansion, there were not that many rivers and waterfalls left to be exploited. Stoltenberg's sentiment was reiterated later that same year by newly elected Prime Minister Kjell Magne Bondevik (2001–05) (*Aftenposten*, 2001). However, the need for energy has kept steadily increasing, and in combination with a few years with little rainfall, the absence of hydropower expansion means that electricity must also be generated elsewhere, the choice for all practical purposes standing between renewable energy and natural gas. In 2000, Bondevik's centrist minority government (1997–2000) refused to go for gas, but faced a hostile parliamentary majority, and was ousted from power, with Stoltenberg's incoming Labor Party government (2000–01) instead giving the go-ahead for several gas power plants. This may have been for several reasons. There was the obvious renewable energy concern about intermittency. Yet, the onus on gas also reflected the government's belief that wind power did not have much potential in Norway, despite the widespread realization that in Europe, in general, wind power would be expanding rapidly (Blindheim, 2013; Hager, 2014).

New renewables

The exploitation of abundant hydropower seems like a very valid reason why solar and wind were never really on the Norwegian energy political agenda. However, it is also conspicuous that when Norway finally did experience a need for more electricity, gas was the preferred option. Thus, as the once dominant electricity provider could no longer be counted upon for further expansion, the preferred solution was to rely on what replaced hydropower as the dominant Norwegian energy-producer, namely petroleum.

The consequence is that Norwegian efforts in new renewables, such as solar PV and wind power, have been feeble. At 856MW of installed wind power capacity, Norway is far behind most other European countries – Germany has 39GW of installed capacity and Denmark almost 5GW – despite having a technical potential for wind power that is more than twice that of Denmark (see also Figure 1.5).[3] The aim is to double the capacity by 2020. In relative terms, this means that the industry will enjoy healthy growth, but in absolute figures, growth is not equally impressive. The year 2014 saw only one single wind farm being erected, and it is not yet clear if any will be built in 2015 (*E24*, 2014b). However, this still represents an improvement, and in the renewable energy attractiveness indices of, for instance, Ernst and Young (2012b, 2014a), in wind power Norway has steadily improved, and is currently ranked 13th out of 40 countries, only a couple of places behind perceived frontrunner Denmark, and up from 18th in 2012, even if Norway's ranking on renewable energy, in general, is a lowly 28. The low overall score has something to do with the total absence of solar policies, but it also reflects a perception that renewable energy simply is not very highly prioritized by the state (Ernst and Young, 2013d).

It may be unfair to compare Norway to Denmark. After all, Denmark is one of the frontrunners of European wind power and in a completely different situation in terms of electricity – Denmark had no hydropower, no oil (at least not until recently), and there was a strong political taboo against nuclear power. Still, in many other respects, Norway and Denmark are obvious candidates for comparison, being Scandinavian countries of fairly similar political cultures and roughly the same population. Thus, in Denmark, wind power rose to become one of the most successful industries, whereas in Norway it survives primarily as a subcontractor, and as can be seen from Table 7.1, in terms of employment, turnover, share of electricity consumption, and capacity, Norway is completely dwarfed by its neighbor.

In 1999, Norway set a goal of producing 3TWh of wind power by 2010. However, it was long clear that this goal could not be fulfilled, and little was done to achieve it. Thus, this goal is abandoned, and in

Table 7.1 Norwegian and Danish wind power figures

	Norway	Denmark
Employment	200–300[a]	27,500[b]
Turnover (million €)	25–40[a]	11,000[b]
Share of total electricity consumption	2%[c]	39.1%[d]
Total capacity (MW)	856[c]	4,845[e]

Notes: [a] Buen (2006); [b] Damvad (2014); [c] *Vindportalen* (projected figure) (2015); [d] *Energinet.dk* (20154); [e] GWEC (2015).

2013 – the best year for Norwegian wind to date – wind power accounted for 2.2TWh, or 2 percent of electricity supply, as compared to roughly 120–130TWh from hydropower (Blindheim, 2013; *Energilink*, 2013; *Vindportalen*, 2015). In 2006, the government introduced a NOK0.08/kWh (approximately €0.01/kWh) subsidy on produced electricity. At the time, this was the third lowest subsidy in Europe (EREF, 2007), and the wind power industry felt that any serious expansion of wind power would have required subsidy levels of more than twice that (*TU*, 2008a, 2008b; *Zero*, 2009). The industry saw the subsidy more or less as an affront and as proof of the lukewarm attitude of the state, and it led to a number of actors essentially just giving up on wind power.[4] The 2 percent of electricity supply from wind compares very unfavorably with Denmark's 39 percent. One should, however, keep in mind that runaway leader China also provides only a little more than 2 percent of its electricity from wind power. Thus, while the Norwegian performance is highly unimpressive, some perspective is still useful.

A new regime sprang to life in 2012, when a green certificate system was introduced in cooperation with Sweden, the idea being that a joint market will permit the trading in certificates in both countries and that an electricity generator can receive certificates in either country. Thus, while Norway and Sweden will fund equal amounts of green electricity, it does not matter in which of the two countries the electricity is actually produced. The joint green certificate market is a resurrection of an already fairly mature idea, as negotiations with Sweden started as early as 2005–06 (before subsequently breaking down). In any case, as a European Economic Area (EEA) member, Norway is committed to increasing its renewable energy share of electricity consumption from 58.2 percent (base year 2005) to 67.5 percent by 2020 (Blindheim, 2013, 2015; *Europaportalen*, 2013).[5] The joint certificate market, through which Norway and Sweden will fund a total of 26.4TWh of green electricity production annually by 2020 (50–50 between the two), is the main policy instrument by which this target will be reached. Also, this happens somewhat out of necessity, as the Norwegian subsidy system for wind power was rejected by the EFTA Surveillance Authority (ESA) (Gullberg, 2013; GWEC, 2012; Hager, 2014).

However, unlike the FIT systems seen in a wealth of other countries, the Norwegian system is not one for the phasing in of wind or solar specifically, but for the phasing in of renewable energy *in general*. Whereas other countries have instituted differentiated tariffs for different forms of renewable energy, based on the maturity of that particular renewable technology (thus, typically higher rates for PV, which is less mature and more expensive than wind), Norway has a system that favors whichever renewable technology is the cheapest. This means that the Norwegian 13.2TWh will probably be split more or less equally between hydropower and wind power. Many wind farms are currently planned, but investors are highly hesitant, as the profitability of the projects under the current system seems dubious.[6] There is nothing wrong with this *per se*. Ideally, it leads to a more cost-effective renewable expansion, as it prioritizes cheap hydropower over more expensive wind and solar. The downside is that it also does not provide any incentives for renewable technologies that are still developing and where the technologies are expected to keep improving for years to come. Another potential downside is that if there is a surplus of certificates, the price of certificates will drop, making it less profitable to invest in renewable energy. This has been a problem since the system was introduced. Thus, since 2012, installed Swedish wind power capacity is estimated to produce 5.2TWh, whereas in the same time interval, Norway's wind power installations amount to a measly 185GWh (Blindheim, 2015; *E24*, 2014b; GWEC, 2012).

Yet, the fact that between 2002 and 2007 talks and negotiations over a certificate system with Sweden triggered wind power concession applications of between 5 and 7GW (as opposed to the accumulated capacity of 0.85GW) (Hager, 2014)[7] suggests that there is a potential for growth and considerable optimism in the business as long as framework conditions are stable and conducive to growth. The expectation of the authorities is that by 2020 capacity should reach 3–3.5GW (*Vindportalen*, 2015). This does, however, require a major increase in the pace of installations.

The fact that the certificate system is not complemented by any technology-specific FIT also means that there is little room for solar PV in Norway. One would think that climate and geographic reasons alone would make PV less than relevant in any case, and as compared to Germany's 38GW and Japan's 25GW of PV, Norway's installed capacity of 0.2MW (in addition to around 10MW that is not grid-connected) (*TU*, 2014c) is among the lowest figures in the Western world. Blaming the weather does, however, ring somewhat hollow when faced with the fact that Denmark almost overnight installed more than 0.5GW.

However, as seen in the China chapter (Chapter 3), some countries have primarily treated solar PV as an export industry, and in this case Norway resembles China. Despite the lack of domestic installations, Norway, for a number of years, had major solar expertise and production capacity and was in the process of building a research cluster around PV. The Norwegian PV industry at times had as much as 10–20 percent of the world market in a number of different PV components, with companies such as Elkem Solar and REC. However, Elkem Solar was sold off to China in 2011 and REC, which in 2012 was a top 15 producer in the world with 2 percent of the PV world market, has been unable to compete with China on price. It closed down all production in Norway in 2012 and moved its solar cell production to Singapore instead. Thus, PV in Norway – as was for long the case in China – was always about exports. And as with Japanese PV, the Norwegian policy was geared toward industrial development, and toward the commercialization of Norwegian technology and industry. It was never about increasing the energy supply, and it was never about reducing GHG emissions (Klitkou and Godoe, 2013; REN21, 2013a; Skjølsvold et al., 2013; *TU*, 2013b).

A vested interest structure biased toward petroleum?

One of the recurring themes of this book is the need for structural change in the energy sector and for an energy transition. Norway is no obvious candidate for such change, but we should not neglect the fact that Norway a few decades ago actually did undergo a structural change, albeit not a renewable one, but one that led the country to become a major petroleum producer. Thus, while this chapter tries to say something about the extent to which the Norwegian petroleum industry undermines the ability of the state to pursue renewable energy, the Norwegian state was once very active in promoting structural change and played a very beneficial role in creating an industry that has been of great benefit to the country, very much unlike how numerous other countries with major mineral or fossil fuel resources have ended up in a resource curse (e.g. Ross, 2012). The Schumpeterian approach advises careful state involvement in strategically important sectors. And especially in a capital-intensive sector such as petroleum, it would be hard for a small country such as Norway to create a domestic petroleum industry without the helping hand of the state. Thus, from the 1970s onward the Norwegian government actively pursued policies of structural change in order to create a new major industry. Norway identified petroleum as a sector with enormous growth potential and did a good job of setting up an institutional structure to cater to its needs. In other words, Norway already has a history of successfully pursuing structural change.

The Norwegian oil company Statoil was founded in 1972 through a unanimous decision in the parliament. It received capital injections from the state until around 1980, with borrowing backed by government guarantees. From 1973 onward, what was also highly beneficial to Statoil was the principle that it should have the right to at least 50 percent participation on all new concessions (Lerøen, 2002). And while all companies were in principle treated equally, there is little doubt that Norwegian companies Statoil, Norsk Hydro, and Saga received the most promising concessions, stemming from a political desire to provide Norwegian actors with favorable conditions (Ryggvik, 1996). In 1971, the parliament's industrial committee published what later became known as the ten Norwegian oil commandments, a document providing strategic guidelines for the development of the petroleum sector. Granted, it contains a 'commandment' on how the oil industry has to take into account existing industrial activities as well as nature and the environment, but the remaining commandments stress government control, state involvement and coordination, the foundation of a state-owned oil company cooperating with domestic and foreign petroleum interests, and the growth of new Norwegian industries based on petroleum (Godzimirski, 2014; OED, 2011).[8]

However, Schumpeter also tells us that government involvement should never become permanent. The state should create favorable conditions for new industries so that they can become competitive and stand on their own industrial feet, but if this involvement keeps persisting even after the industry has become large and healthy, it essentially constitutes a subsidizing of the industries that are already the most powerful. It supports the entrenchment of specific industrial sectors within the apparatus of the state. This is something that stops the process of structural change and prevents the rise of alternative industries.

Therefore, the criticism that has been launched against the Norwegian petro-industrial complex is that it has been such a powerful actor that it unduly influences energy policy (and economic policy in general). The early 1980s saw a number of attempts at limiting Statoil's influence. The Ministry of Petroleum and Energy (MOPE) was not set up to be an institution speaking on Statoil's behalf. Instead, within MOPE there was considerable irritation with the Statoil chairman and his propensity to sidestep the department. The Statoil chairman was hardly any more amused, perceiving of the department as a rival rather than an ally (Lerøen, 2002). But from the 1990s onward, Norwegian energy policy came to center ever more on only one player, namely Statoil. The Norwegian petroleum sector was maturing and consolidating, and politically petroleum policy had become quite consensual, and portrayed as technocratic problem-solving rather than politics (Ryggvik, 1996).

Conservative Prime Minister Kåre Willoch (1981–86) pictures a development where Statoil possessed ever more a monopoly on expertise and policy advice as it grew while other Norwegian oil companies dwindled (this was accentuated further with the 2007 merger of Statoil and Norsk Hydro). The plurality of advice that the state could rely on while Hydro and Saga still prospered now disappeared. Statoil would use its information department to propagate the view that its success was a consequence of the company's infallibility rather than of the major advantages that it was given by the state (Willoch, 1990). Willoch describes Statoil as a state within the state, pushing projects on its own behalf, at the expense of the state, where projects otherwise not economically viable could be forced through parliament with the help of its political, regional, and industrial allies. His general accusation against the Norwegian petroleum sector is that it has used the state to sponsor projects in *its* interest rather than the nation's and used its media access and political influence to gain for itself the policies and regulations that it wanted. And in this, the MOPE has willingly played along. The tab on cost overruns on Statoil projects have for long been picked up by the state (Willoch, 1990, 2002). Thus, by the late 1980s and into the 1990s, many started referring to Statoil and the Norwegian oil industry as the Norwegian oil-industrial complex (Ryggvik, 1996) (which might more accurately be thought of as a petro-industrial complex, since Norway is now more of a gas than an oil producer).[9]

Hence, while the MOPE was not originally meant to be an institution catering to the whims of the petroleum sector, there is little doubt that today, the institutional structure, consisting of the MOPE and the Norwegian Petroleum Directorate (NPD), constitutes a major bias in favor of petroleum and is a major part of the vested interest structure that caters to petroleum interests to the partial detriment of renewables. Let us overlook the obvious rhetorical point that Norway has a Ministry of *Petroleum* and Energy rather than just energy. Instead, it made sense for the state to support the formation of a strong Norwegian petroleum industry, and it should be interpreted as a sign of what is institutionally feasible, and of how the state can change the institutional structure of a country so as to make it conducive to the needs of the most important economic actors.

MOPE and the NPD are the most important institutional and bureaucratic actors, and are now to a large extent allies of petroleum. The industry often recruits from the bureaucracy, whereas the bureaucracy looks for people with industry connections. Careers frequently start at the MOPE, gather pace within the industry, before ending up back in the bureaucracy. The NPD is probably even more pro-industry and many NPD employees consider it their task to actively promote the interests of petroleum against actors that may be seen to express hostility against it or rival it (Boasson, 2005; Holm, 2007; Ryggvik, 1996; Ryggvik and Engen, 2005). The interaction with the industry is close. The notion that MOPE should play a major role in promoting renewable energy seems remote. In 2006, as the wind power industry was arguing for a FIT, the overwhelming impression was one of being stymied by a wall of MOPE bureaucrats, none of which had any belief in wind power. 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 no, it would not, as the bureaucracy would ensure that policies remain stable (Hager, 2014). A small and fragmented Norwegian renewable energy industry makes lobbying hard, and the ability to affect policy has been marginal (Buen, 2006; *TU*, 2007a).

This is indicative of the treatment of renewable energy in Norway. Petroleum policy has increasingly been defined as technocratic problem-solving devoid of political content, whereas renewables has continuously had to justify its existence. No singular department has sole responsibility for environmental policy, whereas there is little doubt about who is in charge of petroleum policy. This has enabled MOPE to prevent measures that go against petroleum (Boasson, 2005; Holm, 2007), by using the argument that Norwegian CO_2 emissions are minuscule and that the Norwegian petroleum sector is subject to more stringent regulations than virtually any other petroleum sector in the world. The same point was made by Frederic Hauge of environmental organization Bellona, who in 2007 blasted the government for having no control over the NPD (*Aftenposten*, 2007). In fact, GHG emissions from oil and gas extraction is the reason why Norway is not able to uphold its climate commitments from the Kyoto Protocol. These emissions have increased by almost 80 percent since 1990 and account for roughly 25 percent of total Norwegian GHG emissions. Thus, they do make a difference. Norway's commitment in the Kyoto protocol was to increase its GHG emissions by no more than 1 percent since 1990. Granted, emissions have dropped pretty steadily since 2007, but in 2013 they were still 3.7 percent above the 1990 level, and mainly because of petroleum, testifying to its enduring, and possibly even increasing, importance in the Norwegian political economy (*Statistics Norway*, 2015). In contrast, sustainable development is very much treated as a notion belonging to the realm of economics rather than environmental politics, and thus subject to cost-effectiveness reasoning (Boasson, 2005). There is no department in charge of coordinating environmental, energy, and industrial policy. Thus, what is lacking in the institutional structure is exactly the kind of cross-boundary institution that would have benefited renewable energy.

The institutions that would typically speak on behalf of renewable energy – the Ministry of the Environment (MOE) and the Norwegian Climate and Pollution Agency (NCPA) – are less influential and far more easily overruled. In an interview with newspaper *Aftenposten* in 2006, previous head of NCPA, Håvard Holm lamented the fact that whereas the climate section of NCPA has 10–12 employees and less than NOK1 million (€125,000) a year for independent analysis and investigations, the MOPE, the NPD, Petoro,[10] the Norwegian Water Resources and Energy Directorate (NVE), and the oil companies employ hundreds of highly qualified people. Further, the MOE and the NCPA are institutions that were established at a time when environmental policy was primarily about toxins and pollutants (Boasson, 2005; Holm, 2007). In other countries, such as Denmark, energy policy has been seen in conjunction with climate policy, and so the Danish wind power lobby has argued that support for renewable energy is one of the most important contributions Denmark can make to reduce its carbon footprint. However, in Norway, the MOE and the NCPA were not designed to take on climate policy, but instead stem from an era when climate change was still only a fanciful theory. Thus, they have not been the avid supporters of renewable energy that one could have expected. Steps have been made to coordinate Norwegian efforts. Thus, in July 2013, the Climate and Pollution Agency merged with the Norwegian Directorate for Nature Management to form the Norwegian Environment Agency (Miljødirektoratet, 2014). While this represents an obvious improvement, what remains is that in terms of turning Norwegian energy production in an environmentally friendlier direction, these have not been very influential players.

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. But the NVE is understaffed for this (it has three to five man-years at its disposal on wind-, gas- and coal-power put together), and a few years ago it was estimated that at current rates, it will take 40 years to get through the wind power applications currently in the system (Blindheim, 2013; *TU*, 2007c; *Zero*, 2009). Capacity has since been ramped up somewhat, but the backlog of cases has only kept growing. For Norway's most recent wind farm (Raggovidda), planning started in 2003, the concession application was approved in 2010, in 2013 the decision to invest was made, and in 2014 the farm finally provided the grid with electricity. On average it takes five-and-a-half years to get a wind power concession through. These years are split between the NVE and the MOPE, neither of which is giving wind much of a priority. But also, most applications (84 percent (2009–13)) are appealed to the MOPE, and this typically delays the concession application by another two years. The time that the MOPE spends on appeals is indicative of its lack of enthusiasm for renewables, and it is not uncommon for applications to take a decade and more. That the 2010 3TWh goal was unachievable was clear as early as 2007, and a major part of the reason for this was that the MOPE itself constituted one of the biggest bottlenecks, both in handling the appeals and in not adequately staffing the NVE (Blindheim, 2013; *E24*, 2014b; *TU*, 2014b).

Another feature of the Norwegian energy political economy is the extent to which it is market-based. For decades, cost effectiveness and technology neutrality have been pillars of the Norwegian renewable energy regime. Thus, few countries worked harder for the introduction of the flexible mechanisms and joint implementation schemes of the Kyoto protocol than Norway, as these arrangements enable Norway to reduce its GHG emissions where it is cost-effective rather than domestically. Thus, unlike in, for instance, Denmark and Germany, renewable energy has not been used as a means to living up to climate commitments. Reducing emissions at home would also have put major strains on domestic industry, which is heavily populated by energy-intensive businesses in addition to petroleum. Thus, both the Norwegian Oil Industry Association (OLF) and the Confederation of Norwegian Enterprise (NHO) lobbied heavily for the flexible mechanisms. The green certificate system is just one of several Norwegian solutions to conform to this ideal. It has many benefits, but as Norway has eschewed differentiated FITs, it is also a system that consistently favors the cheapest form of renewables – in other words hydropower, biomass, and to some extent onshore wind, and very much not solar PV or offshore wind (Blindheim, 2013; Hanson, 2011; Klitkou and Godoe, 2013; Skjølsvold et al., 2013).

The ideals of cost effectiveness and technology neutrality have permeated every main government ministry. Even the MOE has adopted a language of cost effectiveness in order to be taken seriously (Boasson, 2005). In a recent government report on Norwegian climate policy from the MOE (regjeringen.no, 2012), cost effectiveness is explicitly listed as one of the main principles of climate policy. Cost effectiveness and neutrality may indeed seem like a good compass for policy. It does, however, have a series of more or less intended consequences. Neutrality is, for instance, for all practical purposes never neutral. In a technology-neutral green certificate system the state does not provide preferential treatment to less mature technologies, such as PV over, for instance, hydropower. Thus, neutrality preserves the existing system rather than acting as a stimulus for structural change. Cost effectiveness does the same thing. It inevitably plays into the hands of the industries that have had the time to become cost-effective – in other words the established industries, which in Norway means hydro and petroleum. Thus, cost effectiveness and technology neutrality are advocated both by the Ministry of Finance and the MOPE. This is a virtual guarantee against major structural change. Political intervention is mainly reserved for energy-related R&D, with the funding of research centers, but to quote Skjølsvold et al. (2013, p.341): ‘Most political parties agree on the need for some sort of energy transition. However, it is in principle the market participants that decide when a transition is due, based on the information available.’

Thus, the willingness to support projects that are long term in scope has decreased. Enova, which comes under the MOPE, was established in 2001 to promote more efficient energy consumption and (until 2012) new renewables. It does so through targeted investment programs where the greatest effect can be documented. However, this means that cost effectiveness must be documented for a project to be supported even for Enova, because it provides investment support, but not subsidies for its operation. Thus, projects need to be competitive once operative (Skjølsvold et al., 2013), and it is still the case that most wind power projects are not. Simply waiting for the technology to improve and electricity prices to rise effectively means pushing structural change and any energy transition into the unforeseeable future (Hager, 2014; Hansen and Steen, 2011; Moe, 2009a; Solli, 2004).

This does not mean that Norwegian energy policymaking leaves everything to the market. Norway was one of the first countries to introduce a carbon tax (1991). Most of the energy-intensive industry is exempt (only about 60 percent of the CO_2 emissions are covered).

However, petroleum did *not* get an exemption. Thus, despite its influence (which is, however, greater today than in 1991), it does indeed lose battles, and the Norwegian petroleum sector is very heavily regulated. Yet, it is also very clearly at the hub of the Norwegian industrial future. Combined with technological initiatives on Carbon Capture Storage (CCS), the perspective on cost effectiveness and technology neutrality provides for an industrial future where Norway sticks with its existing industrial structure, but at a slightly lower environmental cost. The petroleum industry was no supporter of CCS, thus this political battle was also fought and lost. Yet, for the industry it was a smaller evil than the perceived alternative – a steep carbon tax (Holm, 2007). Marius Holm, then of Bellona, now leader of environmental organization *Zero*, in 2007 commented that CCS preserves the existing structure, but makes it slightly more efficient, pushing structural change ever farther into the future. It is the political glue that unites Norwegian energy and climate policy – both traditionally of higher priority in Norway than in most countries, and because of the vast petroleum production also entailing more conflicting goals than in most other countries – something which probably goes far to explain why the political support for CCS has been so unanimous and persistent. Even environmental organizations actively supported CCS, as a way of bridging the gap between major GHG emissions from petroleum production and ambitious climate goals. For wind power, this is not equally good. It implies an unwillingness to see industrial and energy policy as connected, no recognition of a need for structural change, and consequently no beneficial and stable framework for renewable energy. Quite plausibly, funding for CCS technology and research may have reduced the available funding for renewable energy. The lack of stable renewable policies has been pointed out both in outside reviews, for instance by the IEA (2005), and from Norwegian wind power actors (Blindheim, 2013; Ishii and Langhelle, 2011; Moe, 2009a; Reitan, 1997; Tjernshaugen, 2011), even if the IEA (2011b) now sees signs of improvement.

Ironically, CCS is the one area where the government has seemed only too happy to relinquish all its cost-effectiveness ideals; it has been a non-cost-effective solution to an approach chosen primarily for cost-effectiveness reasons. Prime Minister Stoltenberg (2005–13), in his 2007 New Year's Speech, trumpeted CCS as the Norwegian equivalent of the 1969 moon landing and as something that would become *the* major Norwegian contribution to the world's climate problem (*VG*, 2007). The Technology Centre Mongstad, which is a facility for the testing and improvement of CO_2 capture, started operating in 2012. However, after having been heavily subsidized by the state – steadily pushed into an unknown future, and where it became ever more evident that other countries were making both faster and cheaper progress – in September 2013, the Norwegian government announced that it was cancelling the full-scale Mongstad CO_2 treatment facility (IEA, 2013b, 2014d; *TU*, 2013c). The government's original deal with Statoil, where the government would pay for the technology center and the treatment facility and Statoil for the cost overruns, has come in for heavy criticism. With Statoil being a monopoly player and not facing any competition from other companies in their cost estimates, there has been no incentive to economize. And so, Statoil has been accused of minimizing its own risks by suggesting expensive technological solutions and over-estimating its own costs, so as not to risk any cost overruns it would then have to pay for. Allegations have also been made that the government refused to put climate concerns ahead of Statoil's economic interests (*VG*, 2014). Galloping cost was the Stoltenberg administration's justification for closing down the project, which allegedly increased from NOK5 billion to NOK25 billion (thus, from approximately €0.6 to €3 billion) – the 25 billion figure, however, being controversial, as it refers to a rough and highly contested 2009 estimate (*E24*, 2014a). For three projects in the US and Canada, CCS technologies are already in place and at a far lower cost, whereas Henrik Fleischer, head of CCS-company Sargas Norge, has brought attention to his own company's finished CCS project at one-sixth of Statoil's costs (*Dagbladet*, 2014b; Holm and Andreassen, 2014; *VG*, 2013). The Office of the Auditor General has criticized the laxity with which the MOPE has handled the project, and former petroleum and energy minister Åslaug Haga admits that the relationship between Statoil and the bureaucracy has been tight to the extent that external supervision would have been wise (*Dagbladet*, 2014a; Riksrevisjonen, 2013).

Norwegian human capital is also heavily biased toward petroleum. The industry itself obviously undertakes huge amounts of research, but also much Norwegian Research Council funding is devoted to petroleum, through programs such as CLIMIT, Gassnova, and PETROMAKS/PETROMAKS 2, the latter recently having allotted the biggest amount for petroleum research in ten years. There is a RENERGI program, earmarked for clean energy research, but major parts of this also goes to petroleum. Also, a very high number of engineering doctoral dissertations are partially funded by Statoil. It was, for instance, recently announced that Statoil is allocating $75 million over five years to seven Norwegian (and three foreign) research institutions, including all the major Norwegian universities, for research that is relevant to Statoil, or what one academic referred to as Statoil using academia as a way of optimizing industrial problems (*Forskerforum*, 2013, 2014; *Morgenbladet*, 2013; *Universitas*, 2013).[11] While there is nothing shady about this, it does mean that traditional institutions of research, learning, and education provide partially funded research for those actors that are already the strongest. And while the funding is allocated without formal strings attached (beyond the topics that it is allocated to), there has been criticism that this turns Norwegian academics into stooges of the petroleum industry. Statoil's deal with the University of Bergen, for instance, commits the university to actively promote their work so that it gets a positive reception (*Morgenbladet*, 2013). On a more systemic level, it means that a lot of Norwegian petroleum research is carried out within the existing system boundaries and with a focus on prolonging the oil age rather than promoting any energy transition. It could easily make Norway more resistant to change, and it could make parts of academia into a part of the vested interest structure that has served petroleum so well.

Instead of innovation systems forming around renewable energy, Norway has an innovation system around CCS. Thus, when the KLIMATEK program was established in 1997, promoting R&D in low-emissions technologies, half the budget went to CCS, increasing to three-fourths by 2004. CLIMIT's budget is devoted solely to CCS. Among high-income countries, relative to GDP, Norway has by far the highest funding for CCS (Buen, 2006; van Alphen et al., 2009). In 2010, CCS was awarded almost €30 million over Norwegian public RD&D budgets, accounting for more than 30 percent of Norwegian clean energy RD&D (IEA, 2011b, 2013b; Klitkou and Godoe, 2013). In contrast to this, and very much unlike in, for instance, Denmark, no renewable research hub has emerged. The national innovation system has not been a particularly good fit for renewable energy, and because of the lack of stability in the research funding it has been hard to attract industrial partners and investors (Christiansen, 2002; Fagerberg et al., 2009). Between 1997 and 2007 Norwegian public wind R&D expenditures amounted to roughly €25 million as compared to a Danish figure of €131 million (which probably constitutes only 8–10 per cent of private Danish R&D investments (Megavind, 2010)). Human capital investments have since shot upward, but what is conspicuous is that whereas wind in 2010 received roughly €9 million, PV – for which there has never been a Norwegian deployment program – received €18 million.[12] No research cluster has formed around PV either, but here Norway was for a while a promising actor. It is conspicuous how this to a large part came about through close links between industry, government, and public research organizations, whereas with offshore wind the opposite has been the case, as a main frustration from the industry has been that research funding is allocated to research centers rather than to the commercialization of technologies (Hansen, 2011; Hanson, 2011; Klitkou and Godoe, 2013). This suggests two things: first, that renewable energy beyond hydropower has been funded not from a deployment, but from an export perspective; and second, that as in Japan, industries that are on the inside of the existing structure – as in PV being able to forge important links with other actors – prosper far more easily.

Contributing to the strength of the vested interest structure, and very much affecting the Norwegian political economy of renewable energy, is social and local acceptance. Both Buen (2006) and IEA (2005) list this as an obvious Norwegian problem. Granted, studies show that local and regional opposition is widespread throughout Europe (e.g. Jobert et al., 2007; Nadaï, 2007, Wüstenhagen et al., 2007), and so this is not specifically a Norwegian problem. However, a country such as Denmark has been far more successful in siting its wind turbines, and as a consequence has suffered far fewer local complaints (Nielsen, 2002). In Norway, social acceptance has instead been taken more for granted, and the onus on cost effectiveness has meant that power supply has taken precedent over siting, somewhat irrespective of local concerns. Thus, Norway has ended up with wind farms in exposed and scenic areas rather than in visually less-intrusive locations (Buen, 2006; Karlstrøm and Ryghaug, 2014). Public opinion, in particular through local nature-protection agencies, has actively lobbied against wind power, spreading the message that wind power is ruining large parts of pristine Norwegian wilderness. Gullberg (2013, p.619) provides the following February 2011 quote from The Forum for Nature and Outdoor Life: 'We have enough energy in Norway. The potential for energy efficiency and energy recycling is vastly under-utilised…In the future climate measures will pose a greater threat to the natural environment in Norway than climate change.' An important reason why wind power concessions take as long to get through the system is that almost every application is appealed. In Norway, there is a strong conservationist strand that is generally against both hydropower and wind power, advocating energy conservation, not energy production. However, as the perceived choice has ever more stood between gas and renewable energy, conservationists have warmed up to renewables, and surveys have shown that general support for renewable energy is strong for onshore wind, offshore wind, and hydropower, and that the only energy technology that meets with widespread public mistrust is natural gas without CCS (Karlstrøm and Ryghaug, 2014).

Vested interest loopholes? Offshore wind? Green battery?

So far, what this chapter has suggested is a Norwegian vested interest structure heavily biased toward petroleum, where renewable energy for long has been treated with disinterest. While the petroleum sector is hardly omnipotent, its existence heavily influences policy, and it is no coincidence that flexible mechanisms and CCS, not renewable energy, have been the favored Norwegian approach to reducing Norwegian climate emissions.

However, are there loopholes in the vested interest structure? Does the Norwegian political economy hold promises about an energy transition from areas less affected by the structure, a little like what is the case in the US (Chapter 4)? When Prime Minister Stoltenberg in 2007 compared the Norwegian CCS initiative to the moon landing, the media was quick to brand the government's offshore wind initiatives a second moon landing (*TU*, 2007b). Two years later, then petroleum and energy minister Terje Riis-Johansen proclaimed to be writing history, presenting a framework that would gift Norway yet another future industrial and energy adventure, namely offshore wind power, creating green jobs and new world-beating industries while building on world class Norwegian offshore expertise (*regjeringen.no*, 2009).

Thus, Norwegian offshore wind has had more political goodwill than land-based wind, and the industry was optimistic that in due course necessary government support would arrive. Offshore wind fits far better with the Norwegian institutional and industrial structure than land-based wind, since it draws on expertise within Norwegian specialties such as offshore installations and shipping, and it is an area where established Norwegian actors have been making inroads. Tellingly, out of approximately 100 companies involved in offshore wind, 70 percent are also involved in petroleum or maritime industry, with only 15 percent having offshore wind as the main focus (Hansen, 2011; Hansen and Steen, 2011; Megavind, 2010). Two publicly financed research centers (Nowitech, Norcowe) focus exclusively on offshore wind. However, the concern of the industry is that this research has been of little practical relevance. The basic needs of the industry are about funding and assistance for pre-commercial technology testing and commercialization, and support for demonstration and test projects, thus essentially for the testing of highly capital-intensive technologies. Instead, much of the funding goes to the universities (Hansen, 2011).

The argument has often been made that the potential closeness with the petroleum industry could be an asset. There are far greater complementarities between offshore wind and petroleum than between regular wind power and petroleum. And analyses by the Norwegian Pollution Authority (now the Norwegian Environment Agency) have suggested that in terms of reducing GHG emissions, no singular measure would yield a bigger reduction (albeit at a high financial cost) than the electrification of the Norwegian petroleum industry through offshore wind (*SFT*, 2007).[13] Thus, in 2009, Statoil's Hywind project became the world's first full-scale floating offshore wind turbine. Progress since then has been less encouraging. It is not obvious to what extent offshore wind is an actual priority of Statoil's, or whether it is just environmental window-dressing. Along with the Norwegian energy company Statkraft, Statoil is the operator of two British offshore wind parks, but their profits hinge on subsidies from the British government. Statoil emphasizes that renewable projects have to meet the same profit goals as regular petroleum projects, and their wind power projects yield lower profits and higher risks than petroleum (Bellona, 2009; *TU*, 2012c, 2014a). Thus, while previous petroleum and energy ministers have been sanguine about the prospects of offshore wind, framing this as an industrial opportunity that should not go amiss, optimism has subsided. The previous petroleum and energy minister Ola Borten Moe explicitly denounced offshore wind as simply too expensive, backtracking on the expectations created by his predecessors (*TU*, 2011).

Therefore, while China projects 30GW of offshore capacity within 2020, and while Britain is the runaway leader with 4.5GW of offshore installations and more than 50 percent of global capacity, and Denmark is the world number two with 1.3GW (accounting for almost 25 percent of total Danish installations), Norway stands at a measly 2.3MW (GWEC, 2015). The comparison is somewhat unfair. The Norwegian focus has been on floating turbines – which is where Norway has a potential competitive edge – whereas the British and Danish capacity consists of fixed, non-floating installations. Still, the enthusiasm that once surrounded Norwegian offshore wind turbines has been quelled. This is an area where Norway has the skill base to succeed, but where mixed signals from the government and lack of support have meant that success is more likely to arrive through the supply of equipment and know-how for a much expected European expansion – for instance, through Statoil's involvement with offshore installations off the British coast – than through the deployment of offshore wind on the Norwegian shelf, as there are currently no plans beyond test facilities and research (*Aftenposten*, 2013; Hansen, 2011; Hansen and Steen, 2011; Klitkou and Godoe, 2013, *TU*, 2014a; WWEA, 2014).

A second potential loophole comes in the form of the idea of Norway as a green battery for Europe. The idea is that Norway, with its wealth of hydropower can balance out the fluctuations in power supply in Continental European countries that depend ever more on wind and solar for electricity. Wind and solar are intermittent power producers, and so when the sun does not shine or the wind does not blow, surplus electricity from hydropower could be exported from Norway to Europe, whereas pumped-storage hydropower[14] would allow Norway to store surplus wind and solar power imported from the Continent on those days when wind and solar conditions are particularly good. Apart from the pumped storage, the only thing that would be needed is increased cable capacity. Thus, Norway would have to upgrade its system of interconnectors with the rest of Europe. There are already interconnectors linking the grid to Sweden, Denmark, the Netherlands, and Russia, and Norway and Germany have struck an agreement for a subsea cable to Germany. For six of the ten years between 2000 and 2009 Norway had a power surplus, and Blindheim (2015, p.209) states that in 2020, the Norwegian renewable electricity share will be an estimated 113.3 percent. Thus there is power to export, and there will only be more. However, more cables would be necessary for this vision to come true (Ernst and Young, 2013a; Godzimirski, 2014; Gullberg, 2013).[15]

Economists often argue that wind power in Norway is futile: The increase in power supply only lowers the electricity price (thus increasing consumption). And more electricity from wind power does not replace dirty electricity from coal, since for all practical purposes all of Norwegian electricity is already produced by renewable means. From this point of view wind power is expensive and with no effect on GHG emissions. However, the green battery idea makes this argument fall by the wayside. The more tightly the Norwegian energy market is integrated with the Continent through interconnectors, the greater the utility of Norwegian renewable power and the greater the contribution to global emissions reductions.

Gullberg (2013) does, however, see little reason to expect any radical changes to national policy. Every political party is, in principle, for the idea of exporting renewable energy, and a 2012 White Paper supports the building of interconnectors. Several political parties talk quite highly of renewable energy exports creating economic growth and new jobs both in the electricity sector and in the renewable energy industry. However, this seems more of a long-term scenario, as present policy is very much about incremental change, as in adding new interconnectors, but only when socio-economically cost-effective. Also, pumped storage has never been on the political agenda. The only planned pumped-storage project was put on hold in 2011 for profitability reasons. Thus, the optimism within the electricity sector has somewhat subsided, and Statnett in 2011 postponed and decreased the capacity of new cable connections to Britain and Germany. The argument has also been made that the Norwegian grid network should be upgraded before new interconnectors are built (the grid network is an obstacle to wind power expansion as well – Norway has vast wind resources, but they are typically at their strongest in remote areas where the grid network is weak). Most likely more interconnectors will be built. Most Norwegian politicians as well as several industrial organizations like the idea of renewable energy exports, but policy conforms to regular Norwegian energy policy, being very much market-based and with a focus on cost effectiveness. No structural change seems immediate.

Conclusions

Norway as a country has tried to combine major exports of petroleum and ambitious climate policies. It has grown wealthy from fossil fuels while cultivating an identity as one of the cleanest and environmentally most conscious countries on the planet. It is one of the least likely countries to pursue an energy transition, and still one in which global warming and sustainability are issues that every political party professes to care deeply about.

Squaring this circle has been the main challenge of Norwegian energy policy. Thus, in a country where the continued extraction of oil and gas and the prolongation of the Norwegian fossil fuel age into the unforeseen future is an economic and political given, there are many fairly obvious reasons as to why the Norwegian renewable effort has been rather feeble, despite Norway having one of the greatest wind power potentials in Europe both onshore and offshore. First, the Norwegian focus on CCS, most likely to the partial detriment of renewables, is one that is perfectly suited to the Norwegian industrial structure. It is a solution that allows Norway to keep emitting carbon, but at a slightly lower environmental cost. In other words, it is a solution that pushes any notion of an energy transition into the remote future. And, despite the setbacks at Mongstad, CCS is still very much part of the Norwegian long-term energy strategy.

In addition, almost the entire electricity consumption is covered by hydropower, and for many years there simply was not much of a need for a strong effort within new renewables. Following the 1973 oil crisis, Denmark either had to increase coal imports, invest in nuclear power, or come up with alternative sources of energy. With nuclear not an option, Denmark set itself on a course to becoming a pioneer in wind power. Norway did not face such constraints, both because of the abundance of hydropower and because oil had recently been discovered in the North Sea.

However, it is no longer obvious that Norway can satisfy its electricity needs through hydropower alone (among other things because of the gradual electrification of the transport sector and the potential electrification of the petroleum industry on the Norwegian Continental Shelf), but the preferred policy is still not one of new renewables such as wind, but rather of more gas. It is obvious that the Norwegian petroleum industry is not omnipotent. It has fought and lost several battles against the Norwegian state and is one of the most heavily regulated petroleum sectors anywhere. In 1989, Johan P. Olsen in his book *Petroleum og politikk* concluded that Norwegian institutions had not become 'petrolized'. In other words, politics was driving the petroleum industry, not the other way around. Since then the petroleum sector has grown strongly. There is no doubt that the institutional structure is highly beneficial to the needs of petroleum, whereas the needs of renewables are in no way catered for to the same extent. Here, the vested interest structure is heavily biased toward petroleum and against renewables.

Thus, what we see is a glaring lack of consistency in renewables policymaking and a blatant refusal to link energy policy and industrial policy. Wind power has been developed for energy supply purposes only, whereas PV was exclusively for export purposes, and the same goes for offshore wind. However, no form of renewable energy has been both about energy policy and industrial policy. These are completely de-linked, to the detriment of renewables. The green certificates are accompanied by a national RD&D strategy whereby PV and offshore wind are prioritized. However, as these are the most expensive renewable technologies, under a green certificate system they are also the ones that are the least likely to be installed. Thus, research policies favor PV and offshore wind, and deployment policies favor hydropower and onshore wind (whereas tax policies favor petroleum) (Klitkou and Godoe, 2013).

On the other hand, Norwegian energy policies have also been remarkably stable, in the sense that they, for several decades, have had a distinct market focus, and on cost effectiveness and technology neutrality. In Norway, structural change (if any) comes from innovation, not from deployment. Norway funds R&D, whereas deployment is up to the market. But the lack of a deployment focus also means that to the extent that Norway is contributing to sustainable energy solutions, it does so through the development of technologies and industries that can then export their solutions to other countries. In this sense, the Norwegian approach mirrors both the technology focus of METI in Japan and (until recently) the Chinese PV strategy. The market focus does, however, make it harder to pursue anything along the lines of structural change, as much of the political leverage has been taken away from politicians.

One could of course make the point that it is not certain that the vested interest structure is the main determinant of Norwegian energy policy. It could easily be that the state and Statoil in a number of cases simply have the same policy preferences and thus pursue the same policy outcomes. Norway identified petroleum as a major growth sector for the future and did what it could to promote it, in the interests of the Norwegian people. Up until recently, Norway had little need to pursue particularly ambitious new renewable energy policies. Its energy security is higher than almost anywhere else on the planet,[16] and it produces enough electricity for its own consumption. Times are, however, changing, and with the Norwegian and the European electricity grids becoming more interconnected (and with the rise of the electric car), Norway will need more electricity as well as having the opportunity to export electricity to Europe on a far larger scale. This could lead to policy change. But so far, growth in renewables has been slow and reluctant, and policy frameworks have been less than stable and not particularly generous. And so far natural gas has been preferred over renewable energy. This suggests a future where Norway will remain among the least likely countries to undergo any major transformation of its energy structure. Growth in renewables will probably pick up, but from a smaller base than most other countries, and at a slower speed. Most likely what we will continue to see is a political economy dominated by petroleum, and a vested interest structure that keeps catering to the needs of petroleum first and everyone else second – despite every Norwegian political party marketing itself as green and environmentally conscious.

8
Conclusions

Structural change

The (potential) shift from a fossil-based (and nuclear) energy regime to one based on renewable energy represents one of the biggest structural shifts ever in human history, irrespective of whether we think of it primarily as an industrial shift or as an energy transformation. We know that such shifts have happened in the past. The early Industrial Revolution was based on an energy system that was primarily renewable (i.e. waterpower) (although a renewable system that had undergone a quiet revolution over the past half a century). This gave way to industrial shifts based on coal in the early 19th century. The late 19th century saw the dawn of electricity, and while petroleum in different shapes and sizes was also starting to permeate the world economy, it was in the first few decades of the 20th century that oil became the new wonder fuel. The 20th century also saw the rise of nuclear power, although the nuclear revolution has remained a stillborn one.

These were all revolutionary energy changes. They were Schumpeterian moments in world history, the world's course of development changing from one trajectory to another. These Schumpeterian moments of change in the world's energy structure meant that the world was able to fuel new and more energy-intensive industries and support a higher energy consumption among individual human beings. It led to economic growth and development, and to vastly improved living standards. Energy breakthroughs, providing cheap and seemingly inexhaustible reserves of a new source of energy, have constituted the backbone of the industrial breakthroughs that the world has experienced (e.g. Moe, 2010).

However, today we face a situation where our once cheap and seemingly inexhaustible resources are no longer equally cheap or inexhaustible. So, from where will the next energy breakthrough arrive? Will structural change again bring new prosperity, or will we to an ever greater extent get bogged down in a silted-up old energy regime that stubbornly refuses to change? This book is an attempt at unraveling this. If we agree that renewable energy is at the moment the most credible challenger to the existing fossil fuel energy regime, then to what extent are these renewable energy providers able to rise against a backdrop of industrial energy giants – companies that for decades have had the opportunity to grow economically prosperous and politically influential, companies that have been allowed to influence the structure of government bureaucracies, companies with CEOs who have personal relations with prime ministers and presidents, companies that have had decades to become cost-effective and to develop their technologies to become cheap, efficient, and mature?

For short, in which of the countries discussed in this book do we see the greatest proof of structural change? Do we really see *any* structural change worth mentioning, or is renewable energy a sideshow, and a way to dress up energy policy, so as to make it look nicer? When push comes to shove, are we in fact just continuing to pursue the old, tested and tried energy solutions – because this is the easy path of least resistance – even though we know that this cannot go on forever, or are we serious about making changes to the world's energy structure? Which countries are more serious, and why?

So, what is the answer? The easiest part of the answer is that Norway is the country where renewable energy has had both the least and the most effect. 96–98 percent of the country's electricity is renewable, albeit hydropower, not wind or solar. At the same time, energy policy is clearly dominated by petroleum interests, and wind power has received quite short shrift. Norway is certainly a laggard when it comes to renewable energy beyond hydro, and seems intent on doing what it can to prolong the fossil fuel regime, both domestically and internationally. No *Energiewende* is happening in Norway! To the extent that Norway has made an effort, this has been within CCS, which the previous Norwegian prime minister solemnly professed would be the Norwegian equivalent of the 1969 moon landing, bestowing upon the world a fully fledged technology for the capture and storage of CO_2. Since then, however, the CCS project, despite generous funding, has become preposterously expensive without providing much in terms of concrete results.

The US, Japan, and China all produce approximately 3–5 percent of their electricity by renewable means (not including hydro). Thus, here as well, evidence of structural change is very much in the eye of the beholder. The fact that their renewable energy production is comparable, however, hides major differences between them. The US has seen a series of major renewable policy swings over the past decades, going back to President Carter who genuinely thought that a structural change was occurring, and that the US should lead the way. This gave way to energy policies based almost exclusively on fossil fuels and nuclear, whereas the efforts of President George W. Bush to make the US energy independent had a heavy bias toward biofuels. President Obama is undoubtedly a supporter of clean energy, but attempts at passing energy or climate legislation in what is a very polarized and hostile policy environment have so far proved futile, to the extent that the president has instead used the EPA's authority to regulate harmful gases to impose more stringent regulations on, in particular, coal. The US has seen bigger policy swings than most, more political gridlock than most, more veto players able to block legislation than most, but also more loopholes in terms of regulatory authorities being able to circumvent politics, a huge science sector and a Department of Defense that is quite interested in reducing its operational vulnerability and its fuel bill. Thus, in the US, to the extent that processes of structural change are underway, it is arising from those sectors of the state that are the most sheltered from vested interest pressures. In Japan, Fukushima altered the energy worldview of a lot of the political decisionmaking apparatus, creating the second biggest PV market of the world overnight, and so, there is now a robust Japanese social and political consensus that renewable energy – PV in particular – should be phased in. But the immediate consequence is that Japan is *more* dependent on fossil fuels than before, as renewable energy cannot immediately fill the power gap left by nuclear, and so Japanese GHG emissions have only increased. China very explicitly supports renewable energy, and there seems to be a genuine realization that China will be hit harder than most by climate change. Monstrous pollution problems in the big cities also mean that the energy focus will not disappear, nor will the public unhappiness with the current pollution problems cease. Thus, for as long as China can hold vested interest problems at bay (and this is an important disclaimer), renewable energy will keep being installed at a frantic pace. Is this, however, proof of actual structural change? So far, the answer is at best a very conditional and cautious 'yes'. Energy consumption has increased at such a pace that despite record installations of renewable energy, in terms of the share of electricity production or total primary energy supply (TPES), the change has not been that great. In fact, no country expands its capacity of coal faster than China. Granted, in relative terms, coal's share of TPES and electricity production is decreasing, but in absolute terms coal consumption keeps increasing. Thus, the Chinese renewable expansion is driven as much by steadily increasing energy demand as by an active attempt at pursuing structural change. The fact that wind power output is now greater than nuclear output is certainly both good news and an indication that renewable energy is actually starting to make inroads. There is also good reason to believe that Chinese decisionmakers genuinely understand the seriousness of the pollution and emissions problems that they are facing. Still, at this stage, China has a very long way to go, and unlike the US and Japan, is in a situation where energy consumption will keep increasing for many years still.

That leaves Denmark and Germany, two widely reputed European frontrunners. Denmark supplies 39 percent (and rising) of its electricity by wind power, and Germany almost 13 percent from wind and solar. Denmark has little PV, but the highest density of wind turbines in the world, whereas Germany is the world leader on PV, and has the third largest capacity of wind power. While both countries have had their renewable energy policy swings, out of the six countries analyzed here they are also the only two that have had renewable energy coalitions that have been strong enough to stand their ground against a vested interest structure consisting of fossil fuel, utilities, and in the German case also nuclear. In the four other cases, renewable energy clearly has less influence in terms of lobbying than the traditional energy actors, which are far bigger in terms of energy production. But in Germany, Sühlsen and Hisschemöller (2014) describe the relationship between renewables and traditional energy as one of equality, rather than renewable energy being a niche actor, and the same could be argued for Denmark. That said, in terms of TPES, both Germany and Denmark are still overwhelmingly dominated by fossil fuels, and as some of the wealthiest countries on the planet, they also have some of the largest carbon footprints of any country. And Germany has recently come to the unpleasant conclusion that their widely lauded and emulated FIT system is too expensive, and that renewables now need to be phased in rather more cheaply and cost-effectively.

So, in terms of whether or not structural change is happening, what is certainly part of the answer is that so far no systemic shift has taken place, or even been on the agenda. Whatever change has happened has been well within the existing structures and confines of industrial society. As renewable energy is being phased in, only voices on the political fringes genuinely advocate that industrial society needs to be seriously reorganized. We sometimes hear arguments along the lines of all economic growth models being inherently flawed, and that there is only so much the planet can tolerate: At the hub of the problem is human consumption and human profligacy, and the insistence on economic growth as the one premise that can never be seriously discussed will in due course lead to an environmental breakdown. We may postpone the apocalypse, but unless we fundamentally change our economic ways, it will inevitably happen. Such an approach to systemic change is, however, *not* what we see in the energy policies of any of the countries analyzed in this book. They may have lofty goals about being carbon-free societies by 2050 or so, but these are to be achieved without any major systemic change to the way the economy works. Maybe technological progress will take us all the way there, or maybe an international consensus will arise as to how a carbon tax that actually works can be implemented. The future will tell. The point is simply that all the countries discussed in this book, and dare I say most other countries, have embraced the German notion of *ökologische Modernizierung* (or ecological modernization) (e.g. Dryzek, 2005; Jacobsson and Lauber, 2006). No major sacrifices will be asked of the population (beyond somewhat higher electricity and petroleum prices). Instead, within this sustainable growth paradigm, economic growth goes hand in hand with environmental protection and responsible resource use. Economy and ecology, profits and sustainability all belong to the same paradigm – as does renewable energy; a paradigm of incremental change within existing institutional structures and within the framework of industrial society.

Crisis and change

A widespread notion in the world of Schumpeterian growth is that crisis can often be productive. The Schumpeterian notion 'waves of creative destruction' suggests that creation and destruction are closely intertwined. Disruptive technologies bring about the death of an old industrial or energy regime, while a new regime rises. Disruptive technologies are disruptive because of how they change the ways in which we do things, in which we interact, the technologies that we take for granted, and the industries that produce the economic growth that we depend upon. Crisis lets us break free from the confining structures of the past; it unchains us and allows us to start afresh, unconstrained by outmoded ways of acting, thinking, and producing.

However, it is not always this easy. The first effect of a crisis is destruction. Destruction means disruptiveness, economic recession, social and political chaos. Is it a given that destruction is followed by creation?

Certainly not! This is illustrated very nicely by the fact that the countries that I have examined in this book have all very recently dealt with two crises. Starting in 2008 they have dealt with a worldwide financial crisis, bigger than any financial or economic crisis since 1929, and they have dealt with the 2011 natural disaster cum energy shock that was Fukushima. Granted, they have not been hit equally hard by both crises. Japan was obviously hit far harder by Fukushima than the other countries, and Europe has taken longer to recover from the financial crisis, but these have both been global and defining events.

What we see is that the shock of Fukushima has had a far more profound effect on energy systems than the financial crisis. Granted, the Japanese vested interest structure is strong and, at the moment, there may be a bit of an ongoing backlash against the changes that the DPJ administration sought to institutionalize following the disaster. But what is certainly true is that Japanese energy policy had been gridlocked for decades, and it is now undergoing its most serious rethink for the same amount of decades. Japan has gotten a FIT – even a very generous one – and especially within PV developments have been very rapid. Renewable energy is now routinely spoken of as at least part of the solution to Japan's energy future, by bureaucrats who prior to Fukushima would only talk about nuclear power. The German *Energiewende* was also triggered by Fukushima; Germany more or less overnight decided to phase-out nuclear energy, in a decision that has been politically unanimous to such an extent that it is hard to see nuclear making any comeback in Germany.

Not so the financial crisis. Granted, the financial crisis was a far slower shock than Fukushima, but however a far more protracted one. Schumpeterian thinking would make us believe that such an economic shock would make it easier for politicians to abandon old and stagnant industries and instead go all out for the industries of the future. However, a major crisis could also have the opposite consequence. For politicians who need to be reelected, holding on to what economic activity a country still has may be the difference between political life and death. For a politician it is far easier to continue to support the safe and sound but ultimately stagnant industries, than prospective growth industries for the future. And the austerity measures that most European countries imposed on themselves made unemployment an even bigger problem than before the crisis. Thus, for most European countries this has been an extremely scary environment in which to perform bold economic experiments, even if that may have been what is needed. From China, there is evidence that the authorities used the crisis to boost wind power, as one of several strategic future industries, and as one of several industries that would deliver growth to China through the crisis. But in most other countries, the financial crisis does not seem to have had similar effects. Green growth rhetoric from Western politicians has instead given way to an emphasis on how future renewable energy policies need to be cost-effective, as seen most recently in Germany. Granted, some European countries boldly went for green PV growth, but enormous PV booms gave way to momentous PV busts only a few years later. True, these countries could not have foreseen the drop in PV prices and how this would make their FITs rapidly more expensive. However, the economic crisis was one of the most important reasons why these problems came to such a screeching halt. Instead of propelling change, the crisis put an abrupt end to it.

What then of the green growth argument? If renewable energy technologies are among Schumpeter's disruptive technologies, then sooner or later they should displace existing technologies and become the core energy technologies on which a new wave of growth can be based. So far, the evidence for this is sketchy. Marques and Fuinhaes (2012) conclude that at this stage, growth has not been the consequence, and Frondel et al. (2010) in their analysis of Germany are very doubtful that the net effect of German renewable energy employment has been positive. Increased electricity prices reduce the profitability of businesses and households, and heavily subsidized renewable energy jobs come at the expense of other jobs that they have crowded out. These arguments are all valid. However, so are the arguments pointing out that worldwide fossil fuel and nuclear power receive far greater subsidies than renewable energy. In 2012, renewables received subsidies in the neighborhood of $100 billion. This was dwarfed by the total amount of fossil fuel subsidies, which according to the IEA (2013c) came to $544 billion. Germany subsidizes every coalminer by more than $85,000 (EREC and Greenpeace, 2007). In Japan, Iida (*Japan Times*, 2007) pointed out years ago that the reason why nuclear always used to come out as the cheapest source of energy was that a number of costs were systematically excluded from the calculations, and that if they were all included, wind power (already in 2007) would easily be on par with nuclear in terms of costs. Schilling and Esmundo in 2009 argued that renewable energy was actually doing quite well compared to fossil fuels and nuclear, if only the measure of comparison is changed to performance against cumulative investment. According to this comparison, wind power has exhibited far greater improvements per dollar invested than any other source energy. And, it is also hard to argue against the point that if externalities were included – if, for instance, a carbon price had been introduced – gasoline prices would be maybe two to three times higher than what they are today (coal prices even more than that), whereas for nuclear power, side-payments and decommissioning costs would make the estimates far higher.

However, while this testifies to an uneven playing field between renewables and fossil fuels and nuclear, and that in a miraculously just and fair world, renewable energy would be far more competitive, this does not mean that renewable energy represents a new source of energy that is both cheap and abundant. As long as the present energy system remains intact and renewable energy is added on top of that system, the immediate effect is still more expensive electricity, even if renewables would be relatively less expensive. Therefore, renewable energy *industries* can provide growth to a country through exports and industrial prosperity – this is why China sought to export PV instead of installing it at home – but it is still doubtful if renewable energy itself leads to economic growth. So far green growth has been about industry rather than energy. This may change, but we are not at that stage yet.

FITs or certificates?

Does the book provide any conclusion as to what is the best system for the promotion of renewables? Is a FIT better than a green certificate system? For many years, the FIT has been the gold standard of renewable energy promotion instruments. Germany paved the way in 1990, and as of 2014, 98 states and provinces had enacted different kinds of FITs (REN21, 2014, p.129).[1] The EU Commission in 2008 concluded that 'well adapted feed in tariff regimes are generally the most efficient and effective support schemes for promoting renewable electricity' (EU, 2008, p.3). Thus, there has been a tendency for countries to migrate toward FIT systems. Denmark introduced a FIT in 1993, China started introducing FITs with the 2005 REL, gradually switching from a tendering system, and Japan switched from RPS to FIT in 2009. In the US only a handful states have FIT (or FIT-like) systems. It is also quite clear that the Japanese RPS did not work particularly well (although it could be argued that this was because politicians simply set the quota too low) and that it was the FIT that rejuvenated the Japanese PV market. Likewise, in China, the tendering system was too easily exploited by SOEs, and often resulted in serious underbidding in order to squeeze out the competition. The introduction of a FIT was a definite improvement. In Denmark, during the period where wind power was subject to more market-based policies and having to compete on equal terms with other energy providers, installations came to a complete standstill. Only after 2008, as subsidies were reinstalled, did Danish wind power start growing again.

However, as described in the Germany chapter (Chapter 5), at a time when most major industrialized economies have implemented a FIT, the pendulum has begun swinging the other way. Germany may be phasing out its FIT for good by 2017, the main reason being that the cost of the *Energiewende* is proving excessive. Thus, Germany, having examined the Swedish (and Norwegian) green certificate system, instead of a FIT now wants to introduce a tendering system, where the regulator (the German state) tenders an amount of 2.5GW of wind and 2.5GW of solar a year, whereas green electricity producers compete to sell these. The Chinese FIT system is also becoming more expensive for each year going by as well as being complemented by pilot carbon-trading systems in some of the biggest cities, and the Japanese FIT is so generous that some (e.g. Asano, 2012, 2014) think it is only a matter of time before the system breaks down under its own economic weight. Especially in Japan, which runs large annual budget deficits and has a greater national debt than almost any other industrialized country, it is worth pondering for just how long the tariffs can be upheld. This leaves Norway and the US. Norway is part of the Swedish-Norwegian green certificate system, whereas in the US, California recently set up a large cap-and-trade program. Thus, a movement in the direction of more market-based systems is underway, pretty much at exactly the time in renewable energy history where there seemed to be an overarching consensus about the FIT being the best renewable energy policy instrument.

What are the merits and drawbacks of the two? Whereas FITs are price-based instruments, green certificates and tendering systems are quantity-based. In other words, the FIT guarantees the price for the electricity produced by the renewable energy provider, whereas with the certificates and tendering the quantity of renewable electricity to be produced has been set, and then tendering or quota prices in a market for certificates determines the price for the renewable electricity. The argument against the FIT is that as ever more renewable energy is phased in, the more kWh of renewable electricity will be subsidized every year. Thus, costs are bound to just keep increasing. Against this stands the allure of cost-effective instruments such as certificates and tendering, which will ensure that a certain amount of renewable energy is phased in every year, and at the lowest possible cost. This has appealed to ministries of finance everywhere, and so among the bureaucratic actors, these have been the most eager proponents of such market-based instruments. The main strength of this system is, however, also its main disadvantage. Take the case of Norway, where a cost-effective system for Norwegian renewable energy for all practical purposes means a continued emphasis on hydropower, as this is the cheapest and most mature technology. And while this makes for a compelling argument, it also means that the certificate system does not take into account that some technologies may not be mature yet, but still have major future potential. These technologies will instead have to compete on equal terms with technologies that have had much longer to mature (also, equal terms in this case typically means having to accept an institutional system that is better suited for the older and more mature technologies, a bureaucracy that is more receptive to the needs and requirements of the older and more mature technologies, etc.). Thus, with certificates and tendering systems there is no mechanism for promoting technologies deemed to hold major promise, but that are presently too expensive. PV is, for instance, only now starting to become competitive on price. But it is doubtful whether it would have been if not for the two decades of subsidies that led to the formation of rapidly growing PV markets and to a popular demand for (subsidized) solar cells.

Possibly what we are now seeing is a realization that different support structures are necessary for different stages of renewable energy development. The FIT has been the most efficient tool for rapidly phasing in renewable energy from very low levels, clearly outperforming, for instance, RPS systems. The advantage of the FIT (which is also its main weakness) is that once the tariff has been set, the politicians are no longer in control of the process. The FIT provides long-term stability and predictability for investors, who can now develop as much capacity as they want to, as long as the FIT is high enough for their projects to be profitable. This means that change can actually be faster than what politicians have intended. And because it is possible to have different FITs for different technologies, the FIT can provide stability for different technologies irrespective of which is more mature and costs less. Hence, there is a far greater stimulus for structural change built into this system. The flipside is that when the politicians are no longer in control of the process, there can be coordination problems, as in Germany, where the expansion of PV has been considerably faster than the expansion of the grid network, obviously in addition to the fact that the more renewable energy is installed, the more expensive the FIT becomes. Thus, it could well be that we will see ever more countries changing from FIT-based to more market-based systems as they start bumping up against something like a 20 percent renewable share of electricity production.

Vested interests and barriers to change

The organizing concept of this book is vested interests, or vested interest structures. All states have a number of barriers to change. Without barriers to change, everything would be in a constant state of flux. We need institutions to structure our daily lives and interactions. They are, as economic historian Douglass North (1990) labeled them, the rules of the game. They provide us with stability and predictability. But in stability and predictability also often lies rigidity, a set way of operating, long-established preferences for certain types of solutions and actors, and thus the consequent build-up of vested interest structures. Institutions typically support the already existing actors in the system, and new and upcoming actors have a far harder time getting access to political decisionmakers than does the already existing ones. Thus, major industrial change, or change to energy structures, does not happen simply because new and promising technologies are available, or the price is right. It typically takes political action beyond mere market mechanisms to implement a new energy structure. The present-day, existing energy structures, based on fossil fuels and nuclear, are among the most powerful structures hosting some of the biggest companies that we have ever seen. It would always be hard for renewable energy to rise in the face of such structures.

However, what this book is about is exactly how this has happened in some countries and not in others. And one of the central points is that the reluctance of some states to pursue renewable avenues of energy production on a large scale is inextricably linked to the inherent power and influence residing in domestic and industrial structures. If renewable energy is decidedly on the outside of the vested interest structure, it is inherently difficult to succeed, whereas if it has major support groups within parliaments, bureaucracies, and institutions, not to say public opinion, then this rise will be far easier, and politicians will far more easily make decisions to benefit renewable energy, even if these decisions go against the interests of more established energy actors. This takes us to the crux of the problem. States have limited resources, and they simply cannot prioritize everything. In speeches and rhetorical phrases, politicians may talk about how energy is not an either-or-question, and that we need to phase-in more renewable energy whilst at the same time remaining realistic and remembering that the energy structure is still overwhelmingly carbon-based. But in real life, prioritizing renewable energy often goes at the expense of petroleum, coal, or nuclear. And so, prioritizing renewables often means making decisions that other and more established energy actors will object vehemently against.

Thus, to what extent have renewable energy policies in these countries been impacted by vested interest structures? While other approaches would undoubtedly also reveal valuable insights about renewable energy policy, this book shows that energy is an area in which vested interests are strong, politically influential, and actively and often quite successfully trying to influence energy-political decisionmakers. Politicians obviously do not always cater to the whims of vested interests, but there is little doubt that the most influential energy providers often have the ear of elected politicians as well as strong connections with the bureaucracy.

Japan is one of the clearest cases of vested interest influence, which among other things can be seen in how differently solar PV and wind power have been treated. PV was always on the inside (at least to the extent that it had plenty of institutional support), wind always on the outside. There are a number of reasons for this, such as path-dependencies and the fact that MITI/METI considered the commercial and export potential from solar far higher than from wind. But what has also been conspicuous has been the resistance from the utility companies against wind, and their (sometimes begrudging) acceptance of solar. Wind challenged the utilities to a far greater extent than solar, which could be accommodated more easily and without major changes to the energy infrastructure. With the renewed emphasis on renewable energy since Fukushima, the difference between solar and wind is still conspicuous. More or less overnight, Japan has developed the second largest PV market in the world, whereas installations of wind power have even fallen (they are likely to pick up, but installation targets for PV are still far more ambitious than for wind). Granted, it is not as if solar has led a completely charmed life. As described in the Japan chapter (Chapter 2), solar experienced a major downswing as subsidies were phased out in 2005, and when the FIT was introduced, it was too late for Japan to regain its positions as the world's premier PV producer. Following Fukushima, what we are also seeing is a powerful tug-of-war between different political and energy interests, which may lead to nuclear power being gradually phased back in. Fukushima certainly weakened the old vested interest structure, but there is still much life left in it, even though the rethink to energy policy that has taken place since Fukushima is certainly genuine.

China, on the face of it, does not have major vested interest problems. There is strong government support for renewable energy, to the extent that both solar and wind are singled out as two of several 'new strategic and emerging industries'. Also, growth has been sensational, first for wind power, and then over the past few years for PV as well, where China after years of treating solar as an export industry only now has the largest domestic PV market in the world. What an analysis of China does, however, also reveal is a system that is full of cracks. And some of the problems are not too dissimilar from Japan's. In China it was wind rather than solar which got preferential treatment, and unlike in Japan, wind power was given priority access to the grid early on. But the reluctance that the utilities have shown toward renewable energy mirrors Japan's. Despite priority access, the utilities have often (illegally) just shut wind power out of the grid. It is also conspicuous how decisions made by the central government in Beijing are locally implemented. And with a system that is still more characterized by command and control rather than market mechanisms, regional governments have had to fulfill installation targets set by the central government without much guidance as to how. This, for instance, means that China has a huge off-grid capacity of wind power (since the central government cares more about installations than electricity *production*) and that there has been a lack of coordination between installations and grid expansion. Regional authorities have also exhibited a very strong reluctance to let companies go bankrupt, both in the fear that bankruptcies will cause social unrest and that this would reveal the extent of bad (and preferential) loans that banks have given to PV in particular, bringing the house of cards down in a similar way to what led to the present worldwide financial crisis. While these fears are probably overblown, there is also little doubt that there are massive amounts of bad loans in the Chinese economic system, and that a number of PV companies will have to go bankrupt sooner or later. Thus, China has an unhealthy amount of solar zombies – companies that are not profitable, but which refuse to go away.

What does this tell us about vested interests in China? Among other things, it tells us that the central government is weaker than Western commentators often give it credit for. Chinese economic growth and industrial prowess have led many to believe that China, with its communist party and less of a need to placate voters, can simply decide things, which then magically just happen. That the Chinese system is superior to Western democracies at least in one way, namely that it gets things done. But this is not the case. The Chinese government structure is highly opaque, with overlapping responsibilities and jurisdictions, and with often only weak control with what goes on in the regions. Thus, the regions are where we see clear evidence of vested interest problems. This is where we see utilities shut wind power out, and where we see local authorities give preference to coal over renewable energy. Chinese renewable growth takes place in a system with very obvious tensions, with a central government that enthusiastically promotes it, but where the structure through which renewable energy policy flows is creaking and only moderately able and willing to accept policy directives from Beijing. This means that for as long as Chinese growth can remain as high as it is at present, China will keep installing renewable energy at a rate unrivalled by any other. But if growth rates start dropping, and it is likely they already are, it will be ever more difficult to keep up the effort without serious changes to the system and without picking fights with major vested interests.

Moving from the budding communist superpower of China to the liberal-democratic capitalist superpower of the US, we may not expect to see many similarities. Also, the problems that China is facing are future ones, whereas US renewable energy policies are facing present gridlock rather than potential future problems. But where the opaque Chinese structure of governance makes for an environment that vested interests can easily exploit and where cronyism has often been rife, the rather complicated governance structure of the US, with its many checks and balances and its many potential veto players, has some of the same drawbacks. With legislation having to pass both the House of Representatives and the Senate, and where a 60–40 majority for all practical purposes has now become mandatory in the Senate, and in a political climate that can best be described as toxic, it is very hard to get more than incremental change through the legislature. With US Senators often serving as spokesmen for their respective states rather than for the US as a whole, it has been fairly easy for energy lobbyists, particularly from the coal industry, to influence 'their' Senators to block energy legislation that would be beneficial to renewable energy and potentially harmful to coal. This is especially so because there is no bipartisan consensus on renewable energy. Rather, Republicans, have sided with the coal industry, and Democrats with renewables (apart from the Democrats who represent coal states). This means that it has not been hard for lobbyists to convince Republicans to block a Democratic president from passing energy and climate legislation. As long as the president cannot bypass the legislature, American vested energy interests can flourish and prosper and continue to influence politics.

The US is also different from the other countries for the lack of institutionalization of its renewable energy policy. The lack of a consensus on renewables has led to major policy swings, from renewable euphoria (and naivety) during President Carter to all about fossil fuels during Presidents Reagan and George W. Bush. And then back to President Obama's visions of green growth. But the lack of institutionalization has made the policy swings far greater than in other countries (see, for instance, the US chapter (Chapter 4) on the ups and downs of the PTC), and it has made it far easier for vested interests to bias policy. US success in renewable energy has instead come as a consequence of initiatives taken on the state level, or when the federal government has been able to bypass the legislature by using the bureaucracy or other actors that are relatively sheltered from politicking.

Compare this to Germany, which is also a federal state, but where there has been a robust social and political consensus, as well as *Bundesländer* that have pushed the federal government to be more rather than less ambitious, and we have an example of a country where vested interests have had far less influence, and where consequently politicians have been able to pursue ambitious renewable energy policies relatively unperturbed by interest politics. Germany may have had weaker vested interests to begin with, and so, it may have been easier for renewable energy to grow and prosper here. At the same time, it did have strong utilities, a strong nuclear power sector, and a long history of coal mining. Still, the Feed-in Law, which at the time was probably not envisaged as something that would become a starting point for large-scale renewable energy expansion, was passed in the Bundestag without much protest (also partly because the utilities were busy sharing the spoils from the East German collapse and integration into a united Germany). And in a fairly short time, renewable energy went from being an energy sideshow to a broad coalition of actors, spanning public opinion, research institutes, interest organizations, the renewable energy industry, bureaucrats, and politicians. One could almost argue that in Germany, renewable energy has itself become part of the vested interest structure, one that in terms of power and influence rivals the vested interests of fossil fuel.

But as mentioned earlier, both here and in the Germany chapter (Chapter 5), a major policy swing has just taken place, with the EEG 2014 potentially phasing the FIT out by 2017. Does this mean that when push came to shove fossil fuel vested interests were the more influential after all? Does it mean that the power of the renewable energy coalition was only skin deep? While business interests fought for the policy change and the renewable energy industry against it, there was also a growing realization even within the renewable energy industry that the current system was becoming too expensive, and that reform was necessary. With the commitment of all the major political parties to the ambitious goals of the *Energiewende* (all political parties are, for instance, worried about the fact that an increase in the consumption of coal and lignite are among the paradoxical consequences of the old system), with the strong public support for GHG emissions cuts and for renewable energy, and with the strength of the interest organizations and the more than 370,000 people employed by the renewable energy industry, it is hard to foresee a future in which Germany goes from renewable front-runner to laggard. That said, renewable investment levels have dropped in response to the recent lack of policy predictability, and the mood of the German renewable energy industry is notably less sanguine. The long-term consequences remain to be seen. It is still very early days for this change of policy, and with an election as well as a new EEG reform coming up in 2017, there is much politics to be had before we know for certain where Germany will go.

The other country where renewable energy has developed into a vested interest itself to rival traditional energy providers is Denmark. Here, renewable energy for all practical purposes means wind, in which Denmark has a long history. Here as well, the 1970s oil crises were among the most important energy policy turning points. With nuclear a political taboo, with very little hydropower, (at the time) no petroleum, and precious little domestic coal, alternative means had to be found, and so Denmark ventured on a course that would make it maybe *the* front-runner within wind power. Danish company Vestas has routinely held the largest market share for wind turbines, and wind turbines are one of Denmark's largest export industries. Thus, as in Germany, in Denmark a wind power coalition formed around research institutes, industry, industry organizations, bureaucrats, and politicians, and despite some notable policy swings, few countries have enjoyed more predictable wind power support policies. The most recent swing occurred between 2003 and 2008, but since 2008, wind power support has been strong, and wind power is seen as both a crucial part of Denmark's energy future and an important means to reducing GHG emissions. Denmark is running out of good land areas in which to install new turbines, and so most of the future expansion will probably take place offshore, which will increase costs, but Denmark is expected to keep increasing its share of wind power, even if at 39 percent of electricity production, it is already among the highest in the world, and by far so in this book.

This leaves Norway. Which in at least one sense is the odd man out, namely in the sense that it is an energy exporter, not an energy importer. At the time that oil crises led other countries to research alternative forms of energy, Norway – which already then derived almost all of its electricity from hydropower – had the good fortune to be able to start scaling up its then nascent petroleum industry. Today, Norway is the third largest energy exporter in the world. This means that Norway has had little need to invest heavily in renewable energy (beyond hydro) and that a vested interest structure formed around the petroleum industry, heavily influencing Norwegian energy policy to this day. Thus, it is no coincidence that Norway has opted for CCS instead of wind power, and that few countries have more eagerly advocated flexible mechanisms for emissions reductions, such as purchasing climate quotas, so as to not have to make economically and politically costly emissions cuts at home. Renewable energy has no strong support structure, and within the ministries of Finance and Petroleum and Energy the general attitude has been that alternative forms of energy need to compete on the same terms as hydro and petroleum. The green certificate system that Norway is part of (with Sweden) ensures that Norwegian renewable energy will be cost-effective. That, however, also pushes it in the direction of the cheapest types of renewables, which for Norway means hydropower. It also means that offshore wind, in which Norway would be supremely plentiful, is the type of renewable energy that is the least likely to be installed, the reason being its costs and still fairly immature technologies. The Norwegian petroleum industry does not always get things its way. It is one of the most heavily regulated petroleum industries in the world. Still, there is little doubt that the Norwegian support structure caters to the needs of petroleum first. Norway actively fostered the rise of a domestic petroleum industry. This has brought the country great prosperity. Thus, one could easily argue that the national interest has been heavily overlapping with the interests of petroleum. However, this has also led to the rise of a vested interest structure heavily biased toward petroleum, and it is one that persistently keeps influencing policy in the direction of petroleum. It is one that seeks to perpetuate the present Norwegian fossil fuel regime, but at a slightly smaller environmental cost than before (through, for instance, CCS and measures such as carbon pricing), and to prolong any notion of structural change into an indefinite future.

Some comparisons

So, beyond the role of vested interests, are there any major commonalities, any common themes that recur when we compare the six countries? One thing that stands out is the importance of the utility companies.

This should not come as a surprise. The utilities represent a large-scale, centralized model of energy distribution, whereas renewable energy is often distributed, small-scale, and decentralized. Thus, in most countries, utility companies have doggedly resisted changes to traditional models of electricity generation instead of acknowledging that distributed energy will be an important part of the future and trying to make this new reality into a business opportunity. They have very often been distinctly lukewarm, if not downright hostile, toward renewable energy. Another not so surprising commonality is that the traditional energy providers – coal, petroleum, nuclear – have opposed major changes. Since they typically represent the status quo, and since their interests are the ones being threatened by the growth of renewables, it is no surprise that they have resisted. Thus, both within the US and Germany coal interests have fought against renewable energy, although more successfully so in the US. In Japan, the so-called nuclear village, at least before Fukushima, on numerous occasions ridiculed the potential of renewable energy and steadfastly produced (biased) documents to show how nuclear was far cheaper than the alternatives. Whereas in Norway, the petroleum industry has been so industrially dominant and politically influential that it has hardly had to consider renewable energy a rival, neither in the short nor in the long run.

Something that applies to all the countries, and which is, however, (slightly) less linked to vested interest, is the grid network. These are countries that find themselves in very different situations when it comes to the grid. Japan has no parallel to a European-wide grid to rely on, whereas China is still a developing country, which means that some of its basic infrastructure – such as its grid – is distinctly underdeveloped. However, irrespective of the status of the grid in the different countries, for all six expanding the grid will be as important as anything else when it comes to securing the future success of renewable energy. This applies to China, which has an underdeveloped grid, but which also still provides less than 3 percent of its electricity by renewable means. And it applies to Germany, positioned in the middle of a European grid, which despite all its weaknesses and frailties is still a grid that China, Japan, and the US can only envy. However, in the case of Germany, the reason why the grid is a problem is exactly because Germany has been so much more successful than China, Japan, and the US in phasing in renewable energy. Intermittency problems can be dealt with if the grid only has to accept 3–5 percent of the electricity. But once we start closing in on 20 percent, it becomes harder. Grid expansions will be costly, and if they are to be carried out by the electric utilities, then it is worth considering that these utilities, as a consequence of the influx of renewable energy and the decline in electricity demand from the economic recession, have seen profit margins drop dramatically over the past decade. In the US, something along the lines of $2.1 trillion needs to be invested in the power sector infrastructure by 2035, whereas in Europe the grid infrastructure may need a €1 trillion upgrade by 2020. This is far more than the utilities can realistically finance. The German utilities have posted record losses in recent years. RWE, for instance, lost €2.8 billion in 2013 alone. Thus, while reading the preceding chapters may lead you to believe that the utility companies are among the 'bad guys' of this story, they are very much a necessary part of the solution, and there is no doubt that the expansion of renewables has made it harder for the utilities to do the job that they used to do (*Economist*, 2013e; *Power*, 2014e, 2014f).

Looking at these six countries, it becomes evident that while vested interests have been important in all, they have chosen somewhat different paths. Have the renewable expansions, for instance, been primarily about energy policy (including energy security), industrial policy, or maybe even climate policy? In many of the countries, the 1970s oil crises marked a turning point. This was when Japan, Denmark, Germany, and the US started looking seriously into alternative modes of energy production, primarily for energy security reasons. In some countries, the notion that renewable energy represented new potential export opportunities was also obvious. In both Japan and China, solar PV was as much about building new export industries as it was about energy security. Only as Europe crashed and China was unable to find markets for its production capacity did it seriously start building a home market. It is now the biggest domestic market in the world, but a major part of the decision to promote PV domestically was to provide outlets for the humongous overcapacity held by Chinese PV companies, in order to stave off bankruptcies and unemployment. In contrast, wind power has hardly been an export industry. But China early on identified both wind and solar as industries that would bring future income, either as exports or from industrial growth. China took seriously the notion of structural change in the sense that they saw major growth potential in these industries. That not much structural energy change has actually happened is a whole different matter, but the notion that this could be industrial policy, trade policy, and energy policy all at once was certainly on Chinese minds. As environmental problems have become ever more obvious, renewable energy has also become an important part of climate and environmental policy, but in all likelihood, concerns about climate change are not where the Chinese drive for renewables started.

Germany has also built a number of jobs in the renewable energy sector, and in both Germany and the US, the argument that renewable energy would produce green jobs and green growth, exports and energy production, has been frequent. In Denmark, where wind turbines are one of the major export industries, renewable energy was conceived first as an energy security policy. But as time has passed, ever more wind power has also been thought of as a way in which to fulfill climate commitments. When Denmark seeks a fossil free energy system by 2050, wind power is crucial to this strategy, and also in Germany environmental consciousness in the public is vital to understanding the widespread support for renewable energy, even when this means more expensive electricity. In Norway, however, renewable energy (beyond hydro) has not been used for climate purposes. It has also not been advocated for energy security purposes, as Norway really does not have any such problems. Norway did quite well in solar PV, although exclusively as an export industry. But as China flooded the market, Norwegian companies, as so many others, were unable to compete. Norwegian success within solar is, however, somewhat indicative of the Norwegian approach. Building a domestic market for renewable energy has been a very low priority. In Denmark, renewable energy was always about both demand and supply. In Norway, it has only been about supply, as in increasing electricity production, or as in building a PV export industry. Also, the Norwegian approach has been about supplying technology. But what is conspicuous is that the cost-effective Norwegian approach makes Norway quite uninterested in *installing* expensive renewable technologies, whereas the *research effort* is exactly on these expensive technologies, such as offshore wind power. The underlying argument is that Norway's contribution to the world is not in installing wind turbines at home, but in providing the world with the gift of Norwegian technology, bringing down the costs of renewable energy so that one day it can compete on price. And from then on, the markets will sort the rest out.

And in this sense, the Norwegian approach is quite similar to the US. Granted, given the size and impact of the US, the fact that the US has not developed any coherent policy for deployment of renewable energy at home is a bigger climate and energy problem for the planet than the fact that Norway, with its small population and its reservoirs of hydropower, has not. But what is conspicuous is that also in the US, the main vision seems to be that the US will produce the renewable breakthrough technologies of the future, and, once this happens, the markets will take care of the rest. Once renewable energy is competitive on price, there will be massive investment inflows and the long-awaited structural change away from fossil fuels and nuclear will finally happen. Or so the argument goes.

What this also tells us is that there are major differences between these six countries with respect to whether or not renewable energy policies have had to be cost-effective. In Norway, the answer is clearly 'yes' – the energy political discourse dominated by the Ministries of Finance and Petroleum and Energy and centering on Norway being part of a green certificate system. The US has also been loath to subsidize renewable energy. Thus, there has been no federal FIT, and on the state level RPS systems are far more common. In contrast FITs have been a central part of the renewable energy regimes of Denmark, Germany, Japan, and China. However, as always things are not so black and white. In the first three of these countries, there have been significant swings. Under the leadership of Koizumi, Japan switched to far more market-oriented policies, and during this period PV subsidies were altogether phased out. Looking at installation figures for Japan, it is easy to infer that the policy had negative consequences for PV (even if Asano's (2014) argument about bad technology choices made by the PV industry makes sense), and that the 2009 introduction of a FIT, followed by the 2011 FIT reform, were essential to the upswing in the fortunes of Japanese PV. Denmark during pretty much the same time period also had a government that saw little point in subsidizing a wind turbine industry that was already among the country's biggest and most profitable. The consequence as Denmark re-directed its policies along cost-effectiveness lines was that the years between 2003 and 2008 saw practically no installations. And in Germany, the EEG 2014 reform has taken numerous cues from Sweden in its planned phasing out of the FIT by 2017, and the introduction of a tendering system.

This leaves China as the country which to the least extent has flirted with or re-directed its policies along more market-oriented lines. China used to have a tendering system (which worked only moderately well), but switched to a FIT, inspired among others by Germany. This FIT is becoming more expensive with each passing year – no surprise given the rapid pace of Chinese renewable progress – and so, one should not rule out that China at some stage will end up changing its policies in the same direction, but so far, this does not seem to be on the agenda. One may also speculate that with Chinese growth rates as high as they have been for the past decades China has prioritized production volume over profits in an attempt to becoming the dominant player in potentially important industrial sectors of the future. This has been a huge success in the PV sector, where China currently controls around 60 percent of the world market.

The fact that more market-oriented approaches have typically signaled periods of stagnation for renewable energy does not mean that there is anything wrong with market-oriented policies *per se*. However, cost effectiveness typically benefits the old vested interests, as these are the ones that have had time to become cost-effective, that have had decades to develop technologies and grow markets. Thus, market-oriented policies tend to play into the hands of the already existing actors, and not new and vulnerable actors relying on still relatively immature technologies. But, when market solutions do work, they often work better than anything else. Most likely, the best way of both reducing carbon emissions and boosting the fortunes of renewable energy would be a global carbon tax – although obviously it would first have to be so high as to actually make a difference (and determining what this means is no easy exercise). And it would have to be global, so as to minimize the potential for free-riding. Putting a price on carbon would essentially mean getting the prices 'right', so that consumers (and societies) could choose freely between different types of energy, and not have to think about potential hidden costs that are not taken into account. Market mechanisms would then take care of the rest, without much need for expensive bureaucracy or a labyrinth of rules and regulations.

This argument is, however, based on the premise of everything else being equal. And this is of course never the case. So, in addition to getting the prices right, we also need to get the institutions right, so that there, for instance, is no inherent bias toward fossil fuel vested interests and an institutional interest in making life hard for renewable energy simply because they represent an uncomfortable challenge to existing interests and to long-established institutional preferences. But here as well, things are neither black nor white. On the surface some of these countries are very dissimilar, and with quite different governing structures and institutions, such as Norway and China. The Norwegian energy governance strategy is mainly based on a market philosophy, with the market rather than political actors regulating the pace of implementation. Norway makes a point out of its approach being industrially neutral. Politicians are not playing favorites. Instead, the markets decide which projects are profitable. The Chinese system is to a far greater extent than the other countries analyzed in this book based on command and control. And China's central government has created a system that explicitly favors renewable energy. By law, renewable energy is given priority access to the grid, and a FIT, rather than a certificate system, is the main tool for phasing in renewable energy. Thus, one would expect Norway and China to have radically different renewable energy policies. Obviously, looking at installation figures, it is abundantly clear that they do. However, on a different level, it is not so obvious that the political economy of renewable energy is radically different in the two countries. The Norwegian system is supposed to be industrially neutral, but the way the institutions are set up and the way they work, this neutrality is skin deep and instead leads to certain actors receiving fairly systematic preferential treatment. Thus, in real life this neutrality makes for a systematic bias in favor of petroleum to the extent that the Norwegian vested interest structure can almost be thought of as a petro-industrial complex.

The Chinese system has no qualms about playing favorites. It is explicitly set up to favor renewable energy, and is in many ways the polar opposite to Norway. What we do, however, see are utilities that are distinctly lukewarm toward renewables and simply refuse to let wind and solar into the grid, despite being obligated to do so by law. We see an opaque central bureaucracy with overlapping jurisdictions and responsibilities, where renewable energy despite its elated status in the rhetoric of the politicians does not have particularly strong bureaucratic actors to speak for it. This is a structure that is prone to cronyism and to lobbyism, especially since the Chinese economy to a major extent consists of SOEs, testament to the still considerable overlap between economic and political elites. We see a lack of coordination between regional and central authorities, leading to wind power being installed, but often not connected. We see a deep reluctance to construct new gridlines and to an ever-growing amount of curtailed wind generation. We see regional authorities being lobbied by the thermal companies and ending up favoring coal over renewables as they reap greater profits from coal and because up until quite recently economic growth was the one goal that overshadowed every other. Thus, we see a country where away from the spotlight of the central government there is plenty of room for vested interest actors to maneuver. As suggested earlier, there are strong vested interests hidden not particularly far beneath the surface of the Chinese political energy economy, even if the country's growth has so far been so strong that they have not been very visible.

Thus, Norway has a neutral system that plays favorites, whereas China has a system that is deliberately set up to play favorites, but which does not necessarily do so. The point here is not to say that beneath the surface Norway and China are the same. They are not. The point is rather that vested interests can work through a market system as well as through opaque bureaucracies and formal structures. Two countries may be institutionally very different, but this does not by necessity mean that the politics that flows through these institutional systems has to be very different. Institutions merely constitute the architecture of a system of governance. They are a medium through which political transactions flow. Thus, even if it makes intuitive sense that different institutional setups yield different political behavior and interactions, until we examine the countries and verify if this is actually so, we have no guarantee that the politics that flows through this architecture, the political interactions that are being mediated by the system, will be particularly different. And so, when we examine the politics and interactions that flow through the Norwegian architecture, they are not so radically different from the politics and interactions flowing through the Chinese architecture, despite the architectures being quite different. We would have expected the architectures to make a difference in the behavior of the actors in these systems, but the differences are far smaller than we would have guessed.

On a more general level, sometimes institutions are strong enough and well enough designed that they shape and change the political actions and interactions that flow through them. On other occasions, the actors in the political economy – the vested interests – are sufficiently strong that politics changes very little even if the architecture – the institutions – does. And especially when it comes to the energy sector, which Unruh (2000) has already told us is in a state of 'carbon lock-in' by virtue of being populated by the biggest industrial giants and most powerful companies of world industrial history, it is not obvious that changing the architecture will change the interactions between the established actors of the vested interest structure. The main point then, in picking maybe the two most different countries for a comparison right at the end of this book, is to show that any system can be used and abused, and that unless you have a state that actively stands up for, supports and promotes renewable energy, independently – and often at the expense – of established vested interests, most likely the vested interests will win, irrespective of what the state looks like.

The future?

Government support may take many different forms and shapes. My point here is not to say which is better. All systems have their virtues and vices, and it may also well be that countries that are just starting to phase renewables in need different systems than countries that already derive large parts of their electricity from renewable energy. However, it has been a point of mine to try to say something about how and why renewable energy has grown and prospered in some countries and not in others, to what extent structural change has happened in the energy systems of different countries, and to what extent it has been welcomed. These are interesting times, both in general and for renewable energy more specifically. After years of extremely rapid growth, strong optimism and predictions of future growth along the same lines, the past few years have been far more ambiguous. Since 2008, financial crisis has ridden Europe in particular, but hardly any country has been left unaffected. The crisis has led to renewable investments for the first time dropping for two years in a row (before increasing somewhat in 2014), and it has reduced the size of renewable energy markets, again especially so in Europe. A second reason is that whereas renewable energy for long reigned supreme as the only genuinely credible alternative in a world where an impending peak oil means that we sooner or later will have to turn away from fossil fuels, the potential US shale gas revolution and the current drop in oil prices has made a lot of people think of the old petroleum paradigm as healthier than earlier envisaged, and that shale gas and tight oil can give the petroleum sector a long and glorious Indian summer. The immediate effect of fracking in the US has been to depress the prices on oil and on US natural gas to such an extent that renewable energy despite all its technological improvements and cost reductions suddenly is far less competitive than it used to be, and consequently less attractive for investors. (In the US it has also led to a reduction in the demand for coal.) There are certainly indications that the shale revolution is as much hype as revolution, but in a world that looks for cheap and easy energy solutions before it ventures on to expensive and complex ones, shale more or less by default is bad news for renewable energy. Third, nothing fails like success. In a number of countries, the expansion of renewable energy has been so rapid for so long that further progress is starting to become expensive. It is expensive because the FITs are becoming ever more expensive as more renewable energy is phased in, and because the grid infrastructure needs to be expanded – at huge costs – in order to deal with both the intermittency and the amounts of renewable energy that is fed into the grid.

However, this last point is obviously also good news, in the sense that it means that renewable energy is now actually starting to make a difference. Few countries any longer treat it as an irrelevance, few countries refuse to take renewable energy actors seriously, and most countries think of renewable energy as an essential element of a strategy that is both energy- and climate-oriented. It is of course a worry that renewable investments have been dropping, especially if this becomes a trend, but forecasts still suggest an increase in investments over the next ten years by 60 percent (*Clean Edge*, 2014b). The fact that the world is undergoing an economic recession at the same time as renewable energy policies are becoming more expensive does not seem to have altered the goals and ambitions of most policymakers, even if it has sometimes led to a rethink of policies. A structural transformation away from fossil fuels will have to happen at some stage or another. This means that there is still enormous room for growth in renewables, not the least in developing countries where this growth has hardly even begun. Can it lead to a global energy transformation? The answer can only be tentative and long-winded, and it can hardly be anything other than roundabout. Structural change is a thorny and tenuous process, and one that always meets with resistance from those threatened by it. And in the field of energy, they are both plentiful and powerful. Thus, the transformation of the political economy of energy is not something that will happen just by itself. It will require effort, continued technological progress, and it will require states and governments that are willing to make tough choices, even if these are politically and economically difficult. However, the potential for major growth and major energy production from renewable energy is certainly there. The world still overwhelmingly runs on fossil fuels, and will do so for the foreseeable future. Thus, renewable energy still has not made major inroads into the energy structure of most countries. For that to happen, expansion will have to accelerate at the same time as energy consumption is reduced. In Europe, the main problem with this is that even though energy consumption is falling, renewable energy is no longer accelerating at the same pace as before. Whereas in China, where new capacity is indeed installed at an accelerating pace, consumption is also increasing (and this will also be the case in most other developing countries). Thus, success is not a given. And it could well be that renewable energy becomes an industrial success, but not enough of a success that it becomes the solution to our energy problems and our environmental problems. What this book has done is put the focus on some very obvious pitfalls that need to be avoided in order for renewable energy to become a success. And what we come back to, time and time again, is that the most important pitfall to be avoided is to think that structural transformations – especially such a major one as a genuine energy transformation – will simply just happen. In the Introduction chapter, I referenced Sheikh Yamani's comment that the Oil Age will end long before the world runs out of oil. The problem will take care of itself. However, a rather large number of scholars disagree with this, and this book sides with them, rather than with the Sheikh. If, as suggested in Chapter 1, the current situation is one of a carbon lock-in or a race for the planet's remaining fossil fuel resources (Klare, 2012b; Unruh, 2000), there will be no structural shift, and no energy transformation. This book has instead tried to say something about how lock-in can be escaped.

In order then to transform the world's energy structure, the solution suggested here is a Schumpeterian one. It anchors technological progress in a political-economic framework that preserves the autonomy of the state and enables political decisionmakers to pursue policies of structural change, uninterrupted by long-established vested interests. It argues that without a conscious effort on the part of the state, escaping carbon lock-in will not happen. It is not a foolproof recipe for success, and the fact that almost 80 percent of the world's energy (and electricity) is derived from fossil fuels says something about the size of the task that stands ahead of us. It could still well be our best shot.

Notes

1 Introduction

1. However, according to data from the IEA (2015), from 2013 to 2014 CO_2 emissions did *not* increase, as they remained constant at 32.3 billion metric tons from 2013 to 2014. This is the first time in 40 years that there has been a halt or reduction in GHGs that has not been tied to an economic downturn. It is always risky to make strong extrapolations based on the final year of a data set. This could merely be a temporary pause, but it is still certainly worth noticing.
2. Hydropower accounts for 3.8 percent of global final energy consumption and 16.4 percent of global electricity production (REN21, 2014).
3. Production peaked in 2010 at 93 mb/d. For the past couple of years, production has been flat at 87 mb/d (IEA, 2013c; Yergin, 2011).
4. The IEA (2013c) predicts that existing crude oil fields will lose more than 40 mb/d by 2035.
5. In 2012, US coal exports to Europe increased by 29 percent; European coal prices dropped by a third (*Financial Times*, 2013).
6. According to a 2013 Eurobarometer survey, 74 percent of EU citizens would be concerned if a shale gas project were to be located in the neighborhood (*EREC*, 2013).
7. Early attempts at growth theories by Abramovitz (1956) and Solow (1956) resulted in models that explained no more than 10–20 percent of the variance; the remaining residual of 80–90 percent is often thought of as technological progress, which Abramovitz referred to as 'a measure of our ignorance'. The approach has since been refined, but economic analyses still routinely attribute figures of 50 percent and beyond to technological progress. Thus, technological progress is easily one of the main drivers of economic growth.
8. When I talk about a vested interest *structure* as opposed to just vested interests, this implies a phenomenon that is broader than merely the jostling for power and influence among lobby groups. Concrete interest groups are an obvious part of the structure, but it also consists of the institutions that have sprung up around the main vested interests and of the routines according to which these operate. It is the existence of a whole vested interest *structure* that makes structural change so hard to accomplish.
9. This varies somewhat from year to year, but the only consistent top-ten company that has nothing to do with resource extraction is Wal-Mart (*Fortune*, 2014).
10. What I seek to do is identify major renewable energy-related political issues, relevant interest groups, the extent to which they were successful in influencing policy, and the extent to which political elites were responsive to upcoming (renewable) energy actors. The variable is deductively derived from theory, but since there invariably is a multitude of vested interests, we cannot *a priori* determine which will be the most important in each country.

This can only be established inductively, based on the historical record. The same goes for the actual policymaking influence of these vested interests.

11. The remaining capacity (2013 figures) is divided between biopower (88GW), geothermal (12GW), concentrating solar thermal power (3.4GW), and ocean energy (0.5GW) (REN21, 2014).
12. In terms of wind power, Denmark, for instance, has 112kW/km^2 and Germany 110, compared to China's 10, Japan and the US 7, and Norway 2.5.
13. On December 21, 2013, wind power provided 102 percent of electricity needs (*Energinet.dk*, 2014).
14. The reason why PV yields less electricity than wind despite PV capacity being greater is because wind farms tend to run at higher capacity than solar (approximately 25 vs. 15 percent) (*Economist*, 2014e).
15. According to Bloomberg (2015a) clean energy investments rose by 16 percent in 2014.
16. There is some disagreement on the 2013 figure. Clean Edge's (2014b) figures show only a fairly negligible drop in investments from 2012 to 2013, whereas PEW (2014) has investments drop by 11 percent.
17. In 2012 the US Commerce Department imposed a 31 percent tariff on 61 Chinese solar panel manufacturers, and a 250 percent tariff on another group of PV companies. The EU threatened to impose duties in the range of 37.3–67.9 percent, which were then lowered and finally replaced by minimum prices and quantity limits (*Economist*, 2012a; Ernst and Young, 2013c; *Reuters*, 2013b).
18. German Nordex, Spanish Gamesa, and Indian firm Suzlon are other top-ten companies (REN21, 2014).
19. The levelized cost of power is higher than current cost, as it includes all the costs over the lifetime of the project, such as initial investment, operation and maintenance, cost of fuel, and cost of capital.

2 Japan: No Structural Change, Save for a Structural Shock? Vested Interests Pre- and Post-Fukushima

1. Japan's import dependence on oil is 99.6 percent and natural gas 96.3 percent (2010) (Hayashi and Hughes, 2012).
2. Of these 3 percent, solar produces a little over 1 percent, and wind about half a percent, biomass making up most of the rest (*ISEP*, 2014; *METI*, 2014b).
3. MITI, or the Ministry of International Trade and Industry, in 2001 became METI.
4. Toshiba re-entered the solar power business in 2013 (REN21, 2014).
5. The program entailed a 50-percent subsidy on the cost of installed grid-tied PV systems (Bradford, 2006).
6. Down from ¥270,000/kWh ($3400) in 2000 to ¥20,000/kWh ($250).
7. In 2005, only a little more than 1GW was installed worldwide; five years later, annual installations were more than 15GW, and in 2014 had increased to more than 45GW.
8. However, much of Sharp's recent success has to do with outsourcing of activities to China and Taiwan. Thus, much of what they sell domestically is actually manufactured abroad (Fairley, 2014; *Solarbuzz*, 2014).

9. There are signs of improvement. In 2009, Ernst and Young listed Japan as only the 21st (out of 25) most attractive country for wind power. By 2014, it had risen to 12th (out of 40). This is far behind its solar ranking (3rd), but a clear improvement (Ernst and Young, 2009, 2014b).
10. Known as *ama-kudari*, or descent from heaven.
11. This information was provided by Tetsunari Iida (2009) and Paul Scalise (2009). The utilities are not omnipotent. METI forced deregulation on them, and while they fought this, deregulation ended because METI changed its mind rather than because of pressure from the utilities.
12. The 'Federation of Diet Members for Promoting Natural Energy'.
13. Bills were technically drafted by the (LDP) government, but with the instruction of party committees or research groups. They then go to the LDP Council for Policy Coordination for approval, and then to the LDP General Council for general approval. The LDP committees and research groups have typically been permeated and strongly influenced by the bureaucracy and different vested interests (Grimond, 2002; Sakakibara, 2003).
14. There are many reasons why the DPJ was unsuccessful on energy policy. One is that whereas the LDP was always heavily influenced by METI and the Denjiren, the DPJ has equally close connections to the energy industry labor organizations. These have been very much in line with the Denjiren, thus pro-nuclear and anti-renewables (DeWit and Iida, 2011).
15. Pre-Fukushima, the 2007 Niigata earthquake was the most obvious recent example, causing radioactive leaks at the local nuclear power plant. Other accidents have involved 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 establishing a self-sustaining nuclear fission chain reaction (1999), and scandals over cover-ups of safety inspection procedures (2002) (Scalise, 2004).
16. Two examples: Since 1974 Fukushima prefecture has received a total of ¥188 billion ($2.3 billion) in subsidies and Fukui prefecture more than ¥324 billion ($4 billion) (*Japan Times*, 2011a).
17. METI's 2010 estimate for nuclear power was ¥4.8–6.2/kWh. Iida (*Japan Times*, 2007) suggests that the real figure was typically above ¥10/kWh, and DeWit and Kaneko (2011) suggests at least ¥15/kWh.
18. Japan has also been extremely committed to fast-breeder reactors (FBR). In the 1968 Long-Term Plan, the first FBR was scheduled for the early 1980s. Japan has spent ¥1 trillion ($12 billion) on a prototype (Monju), but, after 50 years of research, the first actual FBR is still not expected until 2050 (*Asia Times*, 2011). Fukushima did not change this. The Noda administration refused to cancel the FBR project.
19. All 54 nuclear reactors being offline could yield extra CO_2 emissions from thermal sources of 170 million tons a year. This would increase Japanese emissions by 14 percent over 1990 levels, rather than reducing them by 6 percent, as stated in the Kyoto Protocol (Hayashi and Hughes, 2012).
20. In a 2007 *Asahi Shimbun* poll, that is long before Fukushima, 64 percent favored promoting renewable energy even if this increased the costs of electricity (Midford, 2014).
21. It also set a goal of increasing solar power generation ten-fold by 2020 and 40-fold by 2030 (Scalise, 2008).

22. The Japanese PV market is now moving toward the non-residential sector, but as late as 2009, 95 percent of all installed PV systems were residential (EPIA, 2010; REN21, 2012, 2014).
23. Mortensen (2009) added that the new framework is biased in favor of Japanese manufacturers as it draws on inputs from domestic producers only, with no foreign manufacturers included in the hearings.
24. Similar accidents, not to nuclear, but to other industrial facilities in the 1960s were among the reasons why Japan went from 'polluter's paradise' to one of the world's cleanest countries (Broadbent, 2002).
25. Fuel imports increased from ¥17.4 trillion in 2010 to ¥21.8 trillion in 2011, up from 3.6 to 4.6 percent of GDP. The cost of fossil fuel imports accounts for more than 30 percent of total imports (DeWit, 2012b; Ernst and Young, 2012a; Hayashi and Hughes, 2012).
26. The average LNG import price in Japan is $16.6 per million Btu vs. $4.7 for thermal coal. Thus, the Abe administration has decided to fund cutting-edge, coal-fired plants and speed up the environmental assessment process for new coal-fired power plants (*Japan Times*, 2013; Umbach, 2014).
27. Nearly ¥3 trillion in total has been provided to TEPCO in financial support, and the government in 2012 took a 50.11 percent share of TEPCO's voting rights (*Japan Times*, 2012a; *TEPCO*, 2013).
28. The LDP and Keidanren went against it, resulting in a compromise whereby energy-intensive industry is given an 80 percent discount on any increase to their electric bill due to the FIT.
29. Japan holds the world's third largest potential for geothermal, estimated at 23.5GW (Midford, 2014).
30. Italy installed 9GW in 2011, but less than 1.5GW in 2013. Spain has discontinued its FIT altogether, and Germany is now looking at a steady 2.5GW a year rather than the 7GW it installed in previous years.

3 China: No Energy Transformation, but Full Speed Ahead. Or…?

1. Energy intensity in 2006 was 2.5 times the world average and 7.2 times that of Japan. By 2014, this had improved to 1.8 times the world average and 3.8 times that of Japan (*China Daily*, 2015b; Zhang et al., 2011).
2. In addition to the tendering system, there is also a more typical command-and-control system of government contracts, whereby proposals are sent to the NDRC (Han et al., 2009). The concession system was introduced in order to create more competition.
3. Introducing a 70 percent local content requirement as a way to water down the worst side effects of underbidding (Zhang, 2010).
4. Including serious technical issues: Blade and shaft fractures, generator fires, gearbox failures (Klagge et al., 2012).
5. In 2011 Sinovel and Mingyang had no exports, whereas Goldwind exported a mere 5 percent of its production (Gosens and Lu, 2014, p.315).
6. The US Department of Commerce has estimated the subsidy to between 2.90 and 4.74 percent (Liu and Goldstein, 2013, p.421).

7. Between 2009 and 2011, the China Development Bank provided extension credits of CNY250 billion and a line of credit of $30 billion for Chinese solar power (Zhang et al., 2014).
8. Suntech most likely got a $32 million emergency loan from a consortium of banks, including the Bank of China, to save it from bankruptcy in 2013 (Zhang et al., 2013b).
9. The agreement with the EU sets a minimum price and establishes a 7GW yearly import quota until 2015 (Ernst and Young, 2013c, 2013d).
10. Liu (2013) suggests that the overinvestment in wind is because companies want to secure access to wind-rich sites. But because profits are scarce and contingent on the support system, it makes sense for wind power companies to pre-empt the competition by securing the rights to particularly promising areas, and then leaving the wind farm off-grid until the support system has improved.
11. In terms of construction costs, wind power is about twice as expensive as a coal plant, whereas the running hours of a wind farm is only half that of coal-fired plants. In addition, the tax on coal-fired power is 0.07 CNY/kWh compared to 0.173 CNY/kWh for wind power (Zhao et al., 2012).
12. One concrete example is Inner Mongolia, where the surplus renewable electricity is transferred to the North China grid because local consumption is too small. However, because of the construction of other wind power plants, the North China grid no longer has the capacity to accept more electricity from Inner Mongolia (Wang, 2014). Thus, total installed wind power capacity has increased, but is being utilized extremely wastefully.
13. For instance, grid-integration technology for PV and high-power, high-efficiency converters, automatic control technology for large-scale PV arrays, sun-tracking technology, and thin-film technology (Lewis, 2013).
14. Schuman and Lin (2012) report a projected CNY710 billion in subsidies for 2011–20. Compare this to German subsidies of €24 billion for renewable energy in 2014 (*Reuters*, 2014b). CNY710 billion equals roughly €90 billion, thus over a ten-year period this is clearly less than in Germany. However, German subsidies have been driven primarily by solar and less by wind, and as China is ramping up its solar capacity at breakneck speed, the CNY710 billion estimate is no longer credible. At the time, China had only installed 3GW of PV (2011), compared to 30GW three years later. Thus, expenses will rise fast. (Germany has 38GW of PV capacity.)
15. Also performing various cameo roles are the Ministry of Water Resources, Ministry of Land Resources, National Forestry Administration, Ministry of Housing and Urban-Rural Development, and the State Oceanic Administration (Wang, 2014).
16. China has the largest hydropower capacity in the world, and keeps expanding it by about 9 percent a year (REN21, 2014; *theenergycollective*, 2014a).
17. As coal utilizes far more of its capacity than renewable energy, coal generates considerably more electricity even if the renewable energy capacity is exactly the same.
18. Beijing, Shanghai, Shenzhen, Guangdong, Tianjin, Chongqing, and Hubei.
19. Production in 2013 was only 200 million cubic meters.

4 The US: Renewable Energy Doing (Reasonably) Well. Despite the State or Because of It?

1. Wind power set a record with 4.8 percent of electricity generation in January 2014 (*Bloomberg*, 2014).
2. In comparison, Europe has 36 billion tons of recoverable reserves, and China 126 billion (Goodell, 2007).
3. Between 2007 and 2012, US carbon emissions dropped by 12 percent to the lowest level since 1995 (*theenergycollective*, 2013d). This is, however, also linked to reduction in consumption resulting from the global financial crisis.
4. Financial stimulus through the American Recovery and Reinvestment Act (ARRA) is probably the main reason why there was no downturn in 2009 following the 11th-hour renewal of the PTC in 2008.
5. And an investment tax credit (ITC) (AWEA, 2013a).
6. Spurred by the California Public Utility Commission's 30-year Standard Offer Contracts, which required California utilities to make purchase agreements for alternative energy (AWEA, 2013b).
7. Kenetech's technologies were purchased by Zond, which was partially bought by Enron, and when Enron collapsed in 2001, GE purchased Zond's technologies to become one of the world's leading wind turbine manufacturers (Mazzucato, 2013).
8. PV investments have stagnated, but because of lower technology prices and the completion of several larger, less expensive utility-scale plants, installation figures are still up (PEW, 2014).
9. The EIA figure corresponds to 250 years of self-sufficiency. This is, however, based on a highly uncertain estimate of what is recoverable, which means that reserves may last far shorter (Goodell, 2007).
10. The biggest renewable energy contributor, the American Wind Energy Association, donated $34,600, 40 percent of which to the Republican Party (Goodell, 2007).
11. Oil drilling in Alaska was removed from the act at the last minute, but for nuclear power there were $13 billion in loan guarantees, $3 billion in R&D and an extra 1.8¢/kWh in operating subsidies for the first eight years and 6GW, as well as federal risk insurance for the builders of the plant (Bang, 2010; Sovacool, 2008).
12. These interests organized themselves and hired lobbyists to work for them in the Washington advocacy group, the Renewable Fuels Association (Coll, 2012, p.445).
13. Coll (2012, p.438) states that on ethanol there was a clear difference between President Bush and Vice President Cheney. Bush felt that he had to take the US in a different direction, while Cheney never thought that ethanol could lead to energy independence. Within ExxonMobil speculation was rife that Bush was afraid of being seen as too close to the oil industry, and that he wanted to distance himself. If true, ironically, the end result was that by distancing himself from one set of vested interests, he fell prey to another.
14. Like the 'Americans for Balanced Energy Choices', 'The American Coalition for Clean Coal Electricity', the 'Kansans for Affordable Energy', and in Illinois the 'Consumers Organized for Reliable Electricity'. These are all dedicated to 'correcting misinformation about coal' (Sovacool, 2008).

15. Coal-to-liquids (CTL) fuel without any carbon sequestration is 118 percent more carbon intensive than gasoline. CTL with sequestration has roughly the same emission levels as gasoline (Bang, 2010, p.1650).
16. Approximately half of these cuts have already been made, since, by 2012, emissions from power plants were already down by 16 percent compared to 2005. The energy sector accounts for one-third of US carbon emissions, most of which stems from coal (*Newrepublic*, 2014).
17. By 2030 coal will still account for 31 percent of electricity production (down from 37 percent today) vs. 9 percent from renewables (*Economist*, 2014d).
18. Vogel (1995), for instance, mentions the 'California effect', stemming from California's large market size, and that when California sets environmental standards, the rest of the country, and eventually the federal government, follows, like with catalytic converters and emissions standards for cars.
19. Energy subsidy estimates vary quite substantially, and so these figures should be treated with caution. 2004 GAO (US Government Accountability Office) figures suggest 86 percent for fossil energy and 6 percent to renewables and energy efficiency (Sovacool, 2008).
20. The comparison may seem biased, since most people assume that nuclear produces far more power than renewables. However, during their first 15 years of deployment, the difference was not that great – 2.6 billion kWh vs. 1.9 billion kWh for wind, and still nuclear subsidies were at least 40 times higher, which is probably even a gross underestimation (Sovacool, 2008).
21. The US still tops the world in terms of investments in biofuel, by a large margin (PEW, 2014).
22. In February 2014, all 45 Republican Senators signed a letter calling on the president to approve the project (*Huffington Post*, 2014b). In February 2015, President Obama vetoed a bill passed by Congress to move forward with the construction of the pipeline (*BBC*, 2015).
23. The bankruptcy meant wasting a $535 million government-guaranteed loan and losing $1.1 billion of private investment (Mazzucato, 2013).
24. Modeled on the DoD's Defense Advanced Research Projects Agency (DARPA) program, which has stimulated research and innovation for the past 50 years.
25. SunPower benefited from DoE research patents and had R&D support from the DoE and the Electric Power Research Institute (Mazzucato, 2012).
26. In wind power, the DoE contributed on aerodynamics, reliability, and efficiency of turbine designs, airfoil design, and siting information.
27. The US alone attracts more than half the world's venture capital/private equity (PEW, 2014).
28. Compared to $11 in Germany, and $17 in Japan (Blackwill and O' Sullivan, 2014).
29. Estimates have ranged from 1 percent to 50! If the former figure is closer to reality than the latter, then ten years of shale gas is a better estimate than 100. For conventional gas fields, recovery rates are typically 75–80 percent (Heinberg, 2013).
30. In 2010, the DoD accounted for 80 percent of the federal government's energy use (Closson, 2013).
31. The DoD in 2008 consumed 120 million barrels at a cost of $16 billion, amounting to 93 percent of federal US oil use. Every US soldier is on average

backed up by 80–85 liters of petroleum per day, and in Afghanistan the US spent on average $100,000 per soldier in fuel (Closson, 2013).

32. Presently geothermal actually contributes more to electricity generation than solar (*EIA*, 2014a).

5 Germany: At a Crossroads, or Social and Political Consensus Setting It on a Course for Structural Change?

1. Ninety-three percent of all Germans support an increasing share of renewable energy (IEA-RETD, 2014).
2. Germany imports 74 percent of its energy (Chowdhury et al., 2014).
3. Thirty-nine percent is imported from Russia, and 35 percent from Norway (IEA, 2012a)
4. As well as 8GW of biomass (REN21, 2014).
5. Yearly sum of global irradiation, $kWh/m^2/year$.
6. Of which wind accounts for 8–9 percent and solar 4.5 (*BMWi*, 2014a; *reneweconomy*, 2014a).
7. See, however, also Tveten et al. (2013) who suggests that increased PV penetration has caused lower prices and less price variability, since PV generation typically peaks during the hours of peak electricity demand.
8. Highest was Mecklenburg-Vorpommern with enough wind to meet 65.5 percent of electricity demand (2013 figures), and enough renewable energy to cover more than 120 percent of total electricity needs (REN21, 2014; *reneweconomy*, 2014c).
9. It was coined in 1980 by a think tank defining it as growth and prosperity without petroleum and uranium (Strunz, 2014).
10. Government-funded renewable R&D in 2007 came to more than €200 million. In 1982, nuclear funding had, however, peaked at more than €1.5 billion (Frondel et al., 2010; Jacobsson and Lauber, 2006).
11. Companies consuming more than 100GWh of electricity per year were allowed to cap additional costs stemming from the EEG (Jankowska, 2014).
12. The exemptions, worth around €5 billion, were investigated by the European Commission as a potential breach of state aid rules. However, a compromise was found whereby 350 of the 2100 companies have to make back-payments of roughly €30 million for 2013 and 2014 (*BMWi*, 2014b).

6 Denmark: An Energy Transformation in the Making? Wind Power on the Inside of the System

1. Denmark has been self-sufficient in petroleum since 1991, but reserves are dwindling, and at current rates, it will be a net importer by 2018 (Sovacool, 2013).
2. With 14.0 percent of the global market share in wind turbines, Vestas in 2012 lost its lead to the US company GE Wind (15.5 percent). In 2013, it was back as number one, although with a market share that has now fallen to 13.1 percent (REN21, 2013a, 2014).

3. In January 2014, the wind power share was as high as 61.7 percent (*Windpower Monthly*, 2015).
4. Danish electricity consumers have the highest level of security of supply within the EU (DEA, 2013).
5. Employment figures obviously vary somewhat from year to year. In 2008, employment peaked at 35,000. Since 2009 it has hovered between 27,000 and 29,000 (Damvad, 2014).
6. There was a change in government in 2001, but 2001–03 saw the finalization of a number of already implemented projects. Thus, not until 2003 did wind power installations come to a screeching halt (Sperling et al., 2010).
7. As of 2014 the DKK0.25/kWh is reduced linearly if market prices reach a certain level, ensuring that subsidies are not allocated to renewables if they are actually competitive on price.
8. Scaled down to DKK0.40 (€0.05) after ten years (IEA, 2011a).
9. Transmission grid company Energinet.dk, for instance, recently delayed a 700MW power cable to the Netherlands (Ernst and Young, 2013a).
10. In addition to Risø, the Technical University of Demark and Aalborg University have developed into valuable wind power research hubs.
11. It should, however, be added that following long-standing lobbying from DONG Energy, in 2008, the government opened the door for more extensive use of coal, despite a goal of becoming more independent of fossil fuel. Hence, other vested interest groups also have policy influence. The government argued that intervening would go against EU legislation, legislation that is first and foremost about cost effectiveness (*Information*, 2008b).
12. In 2002, 80 percent of Danish wind turbines were owned by wind energy cooperatives and individual farmers (Krohn, 2002).
13. The Risø National Laboratory administers the approval schemes for wind power, created by the Danish Energy Agency.
14. A study by Energistyrelsen (the Danish Energy Agency) (2006) suggests that the willingness to pay to have wind farms located out at sea (meaning 18km from the shore rather than 12) is considerable. It increases by 100 percent from 12 to 18 km, and by another 33 percent from 18 to 50km.
15. Denmark is listed 13th in the overall index, 11th on onshore wind, and 6th on offshore. In comparison, Norway is not listed that far behind on onshore wind in 13th (although Norway is 28th on the overall index) (Ernst and Young, 2013d). While the index seems to have something of a big-country bias, what it suggests, however, is a certain convergence between countries, and that the gap between Norway and Denmark has been shrinking.

7 Norway: A Petro-Industrial Complex Leaving Little Room for Structural Change?

1. Through taxation of companies operating on the Norwegian Continental Shelf (roughly 60 percent), the State's Direct Financial Interest (about 30–35 percent), and the state's share of Statoil's profits (approximately 5 percent) (Godzimirski, 2014).
2. Fluctuating from a low of 106.1TWh in 2003 to a high of 143TWh in 2012 (Godzimirski, 2014; REN21, 2013).

3. Seventy-six TWh/year vs. 29TWh/year for Denmark (Buen, 2006). In addition to this comes a potential 18–44TWh of offshore wind (Gullberg, 2013).
4. Ane Brunvoll of environmental organization Bellona states that the support system led to nine out of ten wind power projects being canceled (*TU*, 2007a).
5. This seems achievable considering that as of 2011 Norway was already at 65 percent (REN21, 2013).
6. *TU* (2013a) suggest that a minimum of 7TWh of the Norwegian share of 13.2TWh will come from hydropower, maybe as much as 15TWh. The NVE estimates that new hydropower has a potential for 33TWh of production whereas concessions, notifications, and applications for wind power amount to 43TWh (Gullberg, 2013).
7. Blindheim (2013) states that in 2005, the application volume was approximately 3GW, corresponding to 7TWh. While a lower figure than reported by Hager (2014), this would also by far have been enough for 3TWh/year.
8. 'The ten oil commandments': (1) There should be national supervision and control for all operations on the Norwegian Continental Shelf (NCS); (2) petroleum discoveries have to be exploited in a way that makes Norway independent of other countries for its crude oil supply; (3) new industry should be developed on the basis of petroleum; (4) the development of an oil industry has to take account of existing industrial activities and the protection of nature and the environment; (5) flaring of exploitable gas should not be accepted; (6) petroleum from the NCS has to be landed in Norway, except for when special societal concerns mandate otherwise; (7) the state has to be involved at all levels and contribute to a coordination of Norwegian interests in Norway's petroleum industry; (8) a state oil company was to be established to look after the government's commercial interests and pursue collaboration with domestic and foreign oil interests; (9) a pattern of activities must be selected north of the 62nd parallel so as to reflect the special socio-political conditions of that part of the country; (10) Norwegian foreign policy could face new challenges due to the development of petroleum (Godzimirski, 2014; OED, 2011).
9. Oil production peaked in 2001 at 162.6 million tons. By 2011, it was down to 93.4 million tons (Godzimirski, 2014).
10. 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.
11. Similar deals had also been made in 2009.
12. PV has been more generously funded than wind ever since the 1970s (Klitkou and Godoe, 2013).
13. Potential reduction: 2.7 million ton CO_2 equivalents (against total emissions of 54 million tons a year), or more than twice as much as any other singular measure (*SFT*, 2007).
14. Pumped-storage hydropower means using excess wind power to pump the water back up to the reservoir, and storing it until needed (Gullberg, 2013).
15. Godzimirski (2014) states that six new cables, with a total capacity of 6.7GW, to Britain, the Netherlands, Germany, Denmark, and Sweden are necessary by 2020. Gullberg (2013) refers to Statnett's already envisioned capacity increase of 5.1GW and four new cables.

16. A Danish comparison of self-sufficiency degrees in select countries shows that within the EU, Denmark is the most self-sufficient, at 111 percent. But this fades in comparison to Norway, which has a self-sufficiency degree of 695 percent. For the sake of comparison, Japan stood at only 11 percent, with Germany at 39 and the US at 81 percent (there were no figures for China) (DEA, 2013).

8 Conclusions

1. Some have since removed theirs.

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