Energy Security Initiative
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Transforming the Electricity Portfolio

Lessons from Germany and Japan in Deploying Renewable Energy

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List of Acronyms

ANRE	Agency for Natural Resources and Energy (Japan)
BNetzA	Bundesnetzagentur (German Federal Network Agency)
BMU	Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (Germany)
BMWi	Federal Ministry of Economics and Technology (Germany)
CESifo	Ifo Institute, Center for Economic Studies, Group Munich (Germany)
CO_2	Carbon Dioxide
DC	Direct Current
DENA	German Energy Agency
DICE	Database for Institutional Comparisons in Europe (CESifo)
DOE	United States Department of Energy
EEG	Erneuerbare Energien Gesetz (German Renewable Energy Act)
EEX	European Energy Exchange (Leipzig, Germany)
EIA	U.S. Energy Information Administration
ENTSO-E	European Network of Transmission System Operators for Electricity
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ESI	Energy Security Initiative (Brookings Institution)
ETS	Emissions Trading System (European Union)
EU	European Union
FERC	Federal Energy Regulatory Commission
FIT	Feed-in-Tariff
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt hour
Hz	Hertz
IEA	International Energy Agency
IPP	Independent power producer
ITO	Independent transmission operator
kV	Kilovolts
kW	Kilowatt
kWh	Kilowatt Hour
LCOE	Levelized Cost of Energy

LNG	Liquefied natural gas
METI	Japanese Ministry of Economy, Trade and Industry
mmbtu	One Million British Thermal Units
MW	Megawatt
MWh	Megawatt hour
NABEG	Grid Expansion Acceleration Law (Germany)
NREL	National Renewable Energy Laboratory
O&M	Operations & Maintenance
OCCTO	Cross-regional Coordination of Transmission Operators (Japan)
OECD	Organization for Economic Co-operation and Development
PURPA	The United States Public Utility Regulatory Policies Act
PV	Photovoltaic
RGGI	Regional Greenhouse Gas Initiative (United States)
RPS	Renewable Portfolio Standard
RWE	Rheinisch-Westfälisches Elektrizitätswerk AG
StrEG	Stromeinseisungsgesetz (Electricity Feed-In Law of 1990, Germany)
TEPCO	Tokyo Electric Power Company
TSO	Transmission system operator
TWh	Terawatt hour

Note: At the time of this report, the following exchange rates were in effect: $1 = €0.76, and ¥104.8.

Executive Summary

Amidst near constant reports of the growing inexorable changes in the global climate and the challenges these pose in the absence of a major change in the way the world utilizes energy, Germany and Japan stand out in their energy policy response. These two global economic powers and major export economies are undertaking a dramatic transformation of their electricity portfolios, characterized most prominently by moving away from nuclear energy and toward the large-scale deployment of renewable energy. These decisions were prompted in large part by the March 2011 accident at the Fukushima Daiichi nuclear facility in Japan, which not only put the future of nuclear power in doubt in Germany and Japan, but also sparked a global debate about the safety and costs of nuclear energy.

In both countries, however, fossil fuel use and attendant carbon dioxide (CO_2) emissions have increased as nuclear power generation has decreased. This is occurring even as renewable energy deployment has accelerated. In addition, serious technical, cost, and global economic competiveness concerns have emerged.

The Fukushima accident therefore raises fundamental energy policy questions: Without carbon-free nuclear power generation, what energy sources will take its place and how will national and global greenhouse gas emissions targets be met? What are the challenges and consequences of large shares of renewable energy in the electricity mix? What will be the cost of transforming the electricity portfolio through renewable energy, and who will bear this cost? The answers to these questions are critical for addressing climate change, promoting sustainable global economic growth, and enhancing energy security.

The objective of this policy brief is to examine how Germany and Japan are addressing these questions, and to identify lessons relevant for the large-scale deployment of renewable power in the United States.

LESSONS

Our discussions with stakeholders in Germany and Japan revealed several critical policy, market design, regulatory, technical, and infrastructure-related issues that need to be addressed early and in a cohesive, ongoing manner in order to integrate high levels of renewable capacity. The German and Japanese experiences illustrate just how challenging these issues are, but Germany also demonstrates that these issues can be addressed in a manner that allows renewable energy to play a much larger role in the electricity portfolio of the future.

Countries must set objectives and develop consistent, durable, and clear national policies to manage the complexity of large-scale renewable energy integration. Increasing the share of renewable energy and carrying out a major transformation of the power sector has real and dramatic implications, including cost and wealth distribution impacts. This makes a clear and coordinated

KEY LESSONS

- High levels of renewable energy penetration in the electricity mix are possible, providing a viable option to meet environmental, energy security, and economic goals.
- A large share of renewable energy in the electricity portfolio requires a coordinated transformation of the entire electricity sector.
- Policy must address costs and issues of equity, be tailored to local conditions and market oriented, adaptable and geared toward creating renewable "investors" or "constituents" across a wide swath of society.
- Policy should promote flexible markets and ensure that a comprehensive approach to transmission and operational integration is in place.
- Policymakers need to avoid the creation of large stranded assets and foster regulatory approaches that allow utilities to pursue new business models.

program imperative, starting with setting overall objectives and then developing commensurate policies to achieve them. Policy clarity provides a predictable and stable business environment for utilities and other stakeholders in the electricity industry, allowing them to plan and invest. Germany has been successful in setting objectives and implementing a supportive and stable policy framework, while Japan has struggled since Fukushima to make progress in redefining its overall energy policy owing to ongoing vacillation on the role of nuclear power in the nation's energy future.

For German policymakers, renewable energy is a pathway to achieve the environmental objectives of addressing climate change and phasing out nuclear power, as well as to bolster economic goals (promoting a new industry, creating jobs, and stimulating exports and trade) while enhancing security (reducing energy imports and diversifying supply).

In Japan, policymakers have long been conscious of the need to balance the economic, environmental, and security goals of its energy policy but given the country's overwhelming dependence on imported energy, policy is largely viewed through the lens of energy security. Renewable energy not only provides environmental benefits but also contributes to diversification of the electricity generation fuel mix, strengthening energy security and the economy by limiting imports of expensive fossil fuels. Nevertheless, Japanese energy policy has been in flux since Fukushima as the government continues to fine-tune the specifics of a new approach amidst a heated debate regarding the role of nuclear energy and the suitability and cost of large-scale deployment of renewable energy. This dynamic complicates the government's consensus-building in the development of energy policy, highlighting the importance of a coordinated and centralized approach in transforming the electricity system.

In terms of specific policy mechanisms, the cornerstone of any approach is to promote stable investment conditions that greatly reduce or eliminate market price risk for renewable energy projects. One of the similarities between Germany and Japan is the use of the feed-in-tariff (FIT) at the national level as the primary policy instrument to achieve this goal. Stakeholders in both countries argue that the FIT is superior to quotas or short-term financial incentives, and is the most effective tool in providing a guaranteed long-term revenue stream, stimulating more widespread deployment and bringing costs down.

A high level of renewable penetration presents unique challenges, but is manageable through a coordinated, system-wide approach. High levels of renewable energy in the electricity mix are possible, presenting a challenge less for technical integration than for existing business models and market design (see below). Moreover, this is consistent with the findings of numerous recent studies which conclude that cost-effective solutions exist to address technical and regulatory challenges. These solutions include developing market rules that enable system flexibility, resource diversification, an expanded geographic operational footprint, and improved system operations. In particular, resources such as demand response, storage, and energy efficiency are important tools complementing such a systemic transformation.

In Germany, policymakers have used some of these solutions and are examining others to address the central challenge of enhancing the flexibility of the electricity system as variable renewable generation has increased to account for over 20 percent of electricity consumption.

In Japan, the experience with renewable energy integration is not as extensive and there are several differences with Germany that pose barriers to lowering costs for widespread deployment of renewable energy. These include lack of interconnection with neighboring power markets, geographic constraints (limited suitable land area for some renewable technologies), and lack of competition. Despite these constraints and the ongoing debate over energy policy, it is widely acknowledged that nuclear power's contribution will decrease and that renewables will have an important role in making up the shortfall.

Cost and wealth distribution impacts must be managed. Transformation of the electricity portfolio will entail costs and raise issues concerning fairness over who bears those costs. Consequently, policymaking and market design to drive greater deployment of renewable energy must be carefully considered to avoid large cost impacts and to address stranded assets during the societal transition away from conventional generation.

Critics highlight that transformation of the electricity portfolio in Germany and Japan—in particular eliminating nuclear power and promoting renewable energy—has led to rising costs for households, created severe financial losses for existing utilities, and weakened the economy and industrial competitiveness of both nations. In Germany, where many industries are exempt from paying the costs of the FIT, there are concerns over the inequity of households subsidizing industry to pay for the energy transition. Another frequent criticism is that the FIT is a subsidy for higher-income individuals to deploy expensive renewable energy installations, while the costs of the FIT are borne by lower-income individuals who cannot afford the systems (or those who physically cannot install renewable technologies). Many observers of German policy agree that the FIT was not initially designed with enough flexibility to respond to changing electricity market conditions and especially to declining costs of technology as deployment increased. As a result, the German government has revised its renewable policy to be more market-oriented and to have industry shoulder more of the cost. In Japan, the government has already lowered the FIT to control costs and has proposed a wide-ranging restructuring of the industry in part to facilitate renewable integration and provide greater opportunities for utilities.

Solutions must be tailored to local conditions and include monitoring and course-correction mechanisms. Policymakers should be prepared not only to monitor continually the effectiveness of policy, but also to alter the policy as technology and market conditions change. Importantly, fine-tuning policy or market design should not be viewed as an indication of failure. In Germany, in addition to various changes in the FIT policy over time in line with technology deployment and cost declines, policymakers have focused on how to adapt market design in order to ensure sufficient flexibility to accommodate ever higher levels of variable renewable energy. Establishing formal, periodic policy monitoring mechanisms greatly facilitates this process.

In addition, even supporters of the *Energiewende*[1] do not believe that other countries should follow suit with exactly the same approach and recognize the enormous scope of the challenge. Rather, policy and market design solutions should be adapted and tailored to country-specific local conditions.

Addressing transmission and grid challenges is critical. Addressing transmission and grid challenges is crucial for transforming the electricity sector through significant renewable energy capacity additions. This is especially important when large renewable resources lie at a great distance from demand centers, as is the case in Germany and Japan. Major issues in building new transmission lines include jurisdictional disputes, public opposition, cost allocation, and environmental siting. Germany has also had to deal with issues related to redispatch, curtailments, interconnection with several neighboring countries, and managing the impact of frequency variations on photovoltaic (PV) installations. Japan is confronted with the challenge of ensuring transmission functions and costs are addressed appropriately as part of its proposed electricity sector restructuring.

The key lessons here are: large-scale deployment of variable renewable energy requires new, carefully coordinated grid strategies and added investment in transmission; renewable energy development must be synchronized with grid development and any market restructuring; more interventions are required to stabilize the system, but there are tools and solutions available for system operators, and; there is a need to prioritize and establish formal processes for public consultation in transmission line expansion.

Renewables, especially distributed generation, are forcing changes in utility business models. Renewable energy, especially distributed generation in the form of rooftop solar photovoltaic, is changing the traditional utility business model. The lesson for policymakers is not only to avoid creating stranded assets during the transition to higher shares of renewable energy (as noted previously), but also to design a regulatory approach that allows utilities to adapt and find new ways to earn revenues while meeting the emerging needs of customers.

In Germany, the majority of renewables deployment has been undertaken by households, farmers, and institutional investors. The big four generation companies (RWE, E.ON, EnBW, and Vattenfall) did not invest in renewables for a variety of reasons and are now confronted with little or no market share in the renewables sector. Meanwhile, they are seeing declining sales in an increasingly

[1] German policy under the Energy Concept of 2010 and the Energy Package of 2011 constitute the *Energiewende*. These policy reforms are described in chapter 2.

unprofitable market for conventional generation. As a result, the German utilities are actively looking to change their business model. In Japan, different dynamics are at play, although the resulting impact on the utilities is similar: Those power companies with idled nuclear reactors are not able to generate revenues from those assets and are spending more to buy imported fuels to maintain supply. In addition, Japanese utilities will be affected by the electricity sector deregulation and unbundling proposed by the government.

Markets and industry structure matter. Closely linked to the issue of changing business models is that the transformation of electricity portfolios is taking place within different industry structures and types of markets. Germany is a completely unbundled electricity sector with robust wholesale and retail markets, extensive competition, and interconnection with neighboring systems and regional markets. Japan has a regulated market dominated by vertically-integrated, monopolistic utilities, limited domestic intra-regional interconnection, and no linkages with markets beyond its borders. The presence of organized markets and the ability to interconnect markets greatly enhance the ability to integrate large shares of variable renewable energy. Specifically, organized markets provide more opportunities to adapt and to craft policy and market design elements, and are more efficient in reflecting transparent pricing signals. Operating and monitoring well-functioning markets is an ongoing challenge, especially as renewable energy capacity increases. For example, Germany has had to establish a reserve power mechanism and is actively debating the need for a capacity market to complement the energy-only market.

It is also widely accepted that greater interconnection across markets and larger balancing areas are more efficient in leveraging resources and lowering overall costs. This feature helped in the initial stages of Germany's *Energiewende*, but with higher shares of variable renewable generation in the mix, more coordination with neighboring systems and with the EU's market integration process is needed.

Industry structure also plays a role as increasing competition and more market-based incentives that come with unbundling and deregulation may provide for more adaptability in accommodating variable renewable generation. However, the process of restructuring itself is a challenging endeavor, requiring utilities to dedicate much time and effort not only to adapt to a new way of operating with more competition, but also to undertake time-consuming and challenging corporate organizational change. With unbundling comes the challenge of ensuring that system planning and investment take place as they would in an integrated system. Japan will be facing the challenge of integrating high levels of renewable energy while simultaneously managing unbundling and deregulation of the market, and with the future role of nuclear power still highly uncertain.

IMPLICATIONS FOR THE UNITED STATES: RENEWABLE ENERGY AND THE NATIONAL INTEREST

Renewable energy is an important and growing component of the U.S. electricity portfolio. Renewable capacity additions have grown sharply in recent years, exceeding coal and nuclear additions, and in many locations renewable energy penetration surpasses 10 percent of total electricity supply. From 2006 to 2012, 42 percent of all capacity additions were from renewables (mostly wind), and in 2013 added utility-scale solar capacity was nearly twice that of coal.[2]

[2] See "EIA projects modest needs for new electric generation capacity," Today in Energy, U.S. Energy Information Administration, 16 July 2014; and also "Half of power plant capacity additions in 2013 came from natural gas," Today in Energy, U.S. Energy Information Administration, 8 April 2014.

RENEWABLE ENERGY

A Key Option for U.S. Utilities

In 2012, renewable energy accounted for 17 percent to 21 percent of total retail electricity sales for five major investor-owned utilities—NV Energy, Xcel Energy, Pacific Gas & Electric, Sempra Energy, and Edison International

Source: "Benchmarking Utility Clean Energy Deployment: 2014," Ceres, Inc., in partnership with Clean Edge, Inc., July 2014.

Cost reductions associated with economies of scale have been a major driver in the success of deploying renewable energy. Federal and state policies also have played a vital role. The federal production tax credit has spurred wind capacity additions. At the state level the renewable portfolio standard (RPS) and net metering, along with a variety of other financial and regulatory mechanisms, have boosted renewable energy deployment, especially wind and solar. In addition, many states have developed climate strategies and in the case of California and the Regional Greenhouse Gas Initiative (RGGI) in the Northeast, a cap-and-trade system is employed to place a price on carbon making renewables a more attractive investment.

Despite this progress—and clear evidence of growing shares of renewable energy in certain locations—some observers remain skeptical (if not strongly critical) of renewable energy, and cite Germany's and Japan's move away from nuclear power and the targeting of large-scale deployment of renewable energy as misguided or failed policy. Indeed, some of the same themes and issues emerging in Germany and Japan are common in the United States. However, the challenges confronted by Germany and Japan should not lead policymakers to discard or disparage renewable energy as an important part of the electricity mix. We believe that the findings and lessons described above illustrate important implications for policymakers in the United States looking to craft energy policy; specifically, the experiences of Japan and Germany offer ways in which the U.S. can transform the electricity portfolio as a critical component in addressing climate change. These lessons illustrate key areas that U.S. policymakers should address to ensure a smoother transition to large-scale deployment of renewable energy.

FIRST*, *policymakers must work to build a baseline consensus on national energy objectives and then develop and implement consistent, durable, and clear policy mechanisms to achieve those objectives. In the United States, there historically has been much less consensus on how to balance security, economic, and environmental goals in energy policy than in Germany and Japan. Specifically, the discussion about advantages and disadvantages of increased renewable energy in the electricity mix is complicated by several dynamics, resulting in inconsistent national policy support. These hindrances include a complex and varied institutional and regulatory structure, an ongoing debate over the role of government policy, and the recent shale gas and tight oil boom.

In addition, there is much less agreement in the U.S. on the science and impacts of climate change. Despite the *Energiewende's* costs, German households and politicians remain ideologically committed to the goal of emissions reduction and highly tolerant of the associated costs (although recent increases in household electricity prices have sparked more debate). The fact that concern over climate change and its impacts have not penetrated American politics or society in the same way may be the most significant cultural difference between the two countries. This difference could also explain the American disbelief that Germans can support such a policy despite increasing consumer costs.

As a result of these dynamics, policy in the U.S. is more fragmented. While a variety of federal and state policies are in place supporting renewable energy, no comprehensive national energy policy exists. Though some of these policies have been successful and many experts consider the states in particular to be important leaders in energy policy, our research indicates that a national policy linking energy and climate concerns is necessary to better match utility planning cycles and provide "policy durability" and a more predictable investment climate. Building a perfect consensus on energy objectives is likely unachievable, but constructing a minimal or baseline consensus is vital.

SECOND, the U.S. needs to elevate environmental goals as part of its overall energy objectives—in particular addressing climate change through reduction of GHGs—and link these environmental goals to economic and national security issues. Skepticism about climate change and its impacts is a major factor affecting the debate over energy policy in the United States. While the U.S. government's intensified efforts in the past year to highlight climate change as a critical national policy issue is welcome progress, those efforts must be sustained in order to construct a baseline consensus on energy policy going forward. In particular, policymakers and society at large need to view climate change not just as a strictly environmental issue, but rather one directly linked to economic health and national security. In particular, the economic benefits of responding to climate change are vastly underrated. There are emerging signs that this approach may work to bring all parties to the table to work out a coherent policy.[3]

THIRD, renewable energy needs to be considered a national asset, with the capacity to balance multiple objectives. Elevating the environmental component in energy policymaking does not mean dismissing or decreasing the importance of the other traditional objectives. Rather, as Germany—and increasingly the United States—has shown, transforming the electricity mix by deploying high levels of renewable energy as a low-carbon source of electricity is not only possible, but also effective, viable, and more cost-competitive than previously thought in meeting environmental, economic, and national security goals.

However, there are cautionary findings and lessons from the *Energiewende* in Germany and the situation in Japan, with some of these already evident in the United States. In particular, even with renewable energy playing a key role in the electricity mix to help meet a broad range of objectives, this does not mean that policies should emulate those in other countries. For example, cultural, economic, and industry differences between Germany and the U.S. mean that we cannot expect every element of the *Energiewende* to work in the United States.

In sum, ignoring the lessons identified in this brief is unacceptable: We risk discrediting renewable energy and thereby losing a critical component in combating global climate change, with attendant national security and economic implications. Renewable energy is certainly not the only option for the electricity portfolio. Nevertheless, despite the challenges, renewable energy is a critical, long-term national asset, providing a viable, increasingly cost-competitive option to lower carbon emissions, bolster the economy, create a globally competitive industry, and strengthen national security. U.S. policymakers, industry officials, consumers, and other stakeholders need to view energy-climate policy in this light, and understand the potential for large shares of renewable energy to meet these multifaceted and interrelated goals.

[3] Henry Paulson, "The Coming Climate Crash," *New York Times*, 21 June 2014.

1. Introduction

The March 2011 accident at the Fukushima Daiichi nuclear facility in Japan sparked a global debate about the safety and costs of nuclear energy. In Japan and Germany, the Fukushima accident put the future of nuclear power in doubt while significantly increasing the prospects for large-scale electricity provision from renewable energy, and the timely implementation of demand-side management efforts.

In Germany, the government ordered the country's 17 nuclear reactors—which had provided 23 percent of total electricity generation—to be shut down by 2022. Over the long-term, Berlin expects much of the shortfall in electricity production to be made up through increased deployment of renewables. Germany aims to surpass the European Union's climate policy goals, generating 35 percent of its electricity from renewables by 2020 and 80 percent by 2050 (up from 23 percent today) by way of its ambitious transformative energy policy, known as the *Energiewende*.

Critics of Germany's policy point to its high costs, which could reach €1 trillion by 2030 according to one government estimate.[4] Feed-in tariffs, the cornerstone of the German renewable energy policy framework, have contributed to the second highest electricity retail rates in the European Union. Grid stability and reliability, with higher CO_2 emissions, the high cost of offshore wind, and insufficient transmission capacity are other serious policy concerns dominating the German energy agenda.

Despite these near-term issues, proponents highlight the dynamic success of the policy in spurring an increase in renewable energy from 6 percent of total electricity supply in 2000 to 23 percent in 2012.[5] This increase in renewable energy in electricity generation has created additional environmental, economic, and security benefits. Renewable energy in the electricity sector is estimated to have saved Germany €11 billion from 2009 to 2012 in fossil fuel imports and avoided 101 million tonnes of GHG emissions in 2012 alone.[6] In addition, there has been robust investment in the country's energy sector, a burst of technology innovation, and the creation of 377,000 jobs leading to Germany's emergence as a global lead-

[4] "German 'Green Revolution' May Cost 1 Trillion Euros – Minister," *Reuters*, 20 February 2013, http://www.reuters.com/article/2013/02/20/us-germany-energy-idUSBRE91J0AV20130220.
[5] "Renewable Energy Sources in Figures: National and International Development," Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), July 2013, 13.
[6] Ibid., 12 and 29.

er in renewable energy.[7] Supporters believe that the *Energiewende* will provide the foundation for Germany's economic growth in the 21st century, positioning the country at the forefront of manufacturing and technology development of the global, low-carbon economy. Moreover, the government and other supporters view the *Energiewende* as a model for other countries, even suggesting that the fate of the global battle to combat climate change hinges on Germany's success.

In Japan, the government has come under increasing pressure from both a public that no longer considers nuclear power to be as safe and reliable as before and a strong business community concerned about the rising cost of imported energy. Without nuclear power, Japan—a country that was highly dependent on imported fuel even before the accident—has suffered severe economic consequences associated with an increased dependence on imports. In 2011, the country posted its first trade deficit in recent memory, owing in large part to the combined effects of increased imports of liquefied natural gas (LNG) and coal. To address lost nuclear capacity and rising import dependence, the government has increased energy conservation efforts and announced a target to increase renewables to 20 percent of its energy portfolio by the 2020s.[8] In addition, based on discussions that began in 2009, the government launched its own FIT policy in July 2012. Despite these policies, continuing negative economic impacts from the nuclear shutdown prompted the government in the spring of 2014 to release a revised national energy policy that proposes restoring some nuclear capacity to the mix.[9]

While Germany and Japan have made national policy decisions to phase out or reduce nuclear power generation largely because of environmental and safety concerns, in the United States the Obama administration has reiterated its support for nuclear power in the aftermath of the disaster at Fukushima. A number of difficult decisions, such as implementing the recommendations of the president's Blue Ribbon Commission on nuclear waste, have yet to be made. However, to be fair, the shale gas revolution has transformed the electricity sector. Nuclear power is expected now to play a diminishing role in the U.S. as low natural gas prices threaten the operating economics of existing nuclear plants in competitive wholesale markets. In addition, fuel switching from coal to natural gas has contributed to the lowest CO_2 emissions since 1992. Meanwhile, with policy support from the Obama administration, non-hydro renewable capacity has increased from 41 GW to 85 GW between 2008 to 2012.[10] Nevertheless, these sources currently account for only 5 percent of total electricity generation, and cheap natural gas and reduced government policy support in an era of fiscal austerity could undermine the continued deployment of renewable energy capacity.

The shale gas boom in the U.S. has also had ramifications internationally, including for Germany and Japan. With cheap natural gas in the U.S. severely limiting the domestic market for coal-fired generation, U.S. coal exports are at record levels, with exports of steam coal to Germany alone tripling between 2010 and 2013.[11] In addition, large volumes of shale gas production in the U.S. have

[7] Renewable Energy Sources in Figures: National and International Development," Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), July 2013, 23.

[8] Chico Harlan, "Japan takes a shine to renewable energy," *The Washington Post*, 27 May 2011, http://www.washingtonpost.com/pb/world/asia-pacific/japan-takes-a-shine-to-renewable-energy/2011/05/26/AGm8wuCH_story.html.

[9] "4th Strategic Energy Plan," Ministry of Economy, Trade and Industry of Japan (METI), April 2014, http://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf.

[10] See Rachel Gelman, "2012 Renewable Energy Data Book," NREL, U.S. Department of Energy, November 2013, 22.

[11] See U.S. EIA's Coal Data browser at http://www.eia.gov/beta/coal/data/browser/#/topic/41?agg=2,1,0&rank=ok&linechart=COAL.EXPORT_QTY.TOT-TOT-TOT.A&columnchart=COAL.EXPORT_QTY.TOT-TOT-TOT.A&map=COAL.EXPORT_QTY.TOT-TOT-TOT.A&freq=A&ctype=map&ltype=pin&rtype=s&pin=&rse=0&maptype=0.

spurred interest in developing U.S. exports of LNG, with Japan representing a major potential market. Generally lower energy costs in the U.S. relative to those in Japan and Europe provide a competitive advantage for U.S. industry, with major geopolitical implications.[12]

In sum, while circumstances like market trends and policies differ, Germany, Japan, and the United States all confront the need to transform their electricity portfolios over the next several decades. All three nations also share the challenges of how to deploy much larger volumes of renewable capacity while relying less on nuclear power. As a result, each country must address several core challenges:

- Developing and implementing a policy and regulatory framework to promote the deployment of affordable renewable capacity in a manner that supports economic growth
- Ensuring reliability and security of the grid, especially by developing adequate transmission capacity and carefully planning operational integration of renewable energy
- Meeting climate change and other environmental challenges consistent with regional and international obligations, as well as with economic goals
- Enacting policies that contain costs and ensure that large stranded assets are not created during the societal transition away from conventional generation toward renewables

As large, industrialized economies facing competition from emerging markets, Germany, Japan, and the U.S. also share an incentive to innovate and develop new energy sources that give them a global competitive advantage. Moreover, Germany and Japan have economic and national security incentives to reduce reliance on hydrocarbons in the electricity sector. The economic health and energy security of these allies have repercussions for the United States.

Thus, these three countries have strong incentives to cooperate on strategies for clean energy development, energy-efficiency measures, and other low-carbon approaches such as carbon capture and storage. As three of the world's leaders in renewable energy technology development, deployment and financing, they also share the advantage of having research and manufacturing bases and capital markets to support a large-scale increase in wind and solar power.

By sharing knowledge and lessons learned in tackling the technical economic and political challenges of a large-scale switch to renewable energy, Japan, Germany, and the United States have the opportunity to collaborate to their mutual benefit, and to the benefit of the global community.

METHODOLOGY AND ASSUMPTIONS

To address these issues, ESI has examined the approaches, progress, and challenges of Germany and Japan as those countries move to replace all or some nuclear power generation and deploy much higher shares of renewable energy. In particular, ESI sought to identify aspects and themes in the German and Japanese experiences which have relevance for large-scale deployment of renewable power in the United States.

ESI recognizes that promoting renewable energy constitutes one part of an overall policy approach. There are other key, complementary aspects of a comprehensive energy-climate policy in each country, ranging from other low-carbon generation options, research and development, energy efficiency and demand-side management measures.

[12] International Energy Agency, "World Energy Outlook," November 2013, 276.

ESI also recognizes the need for a cohesive policy to extend to other sectors, including buildings, heat, and transportation. However, given the decision by two of the world's leading economies to move away from nuclear power and increase the role of renewable energy in their electricity portfolios, we have focused on the electricity sector and issues surrounding renewable energy policy. This analysis is not intended to be a detailed examination of all aspects of policy implementation in both countries: Rather, we concentrate on key themes and issues arising in the course of our discussions and research. In addition, it is beyond the scope of this research to assess in depth the history and context of each country's decision with regard to nuclear power, or more broadly whether nuclear power should be a part of their respective electricity portfolios.

Brookings convened roundtable discussions in Berlin and Tokyo involving participation from host country policymakers, corporate executives (including representation from utilities), academia, research institutions, and representatives from civil society. In addition, counterparts from the other two countries (as well as from the United States) attended each meeting. The roundtables were moderated discussions under Chatham House Rule, in which participants address key themes but cannot publically attribute any comments or viewpoints to any specific individual or institution.[13] The goal was to use the substantive discussions and findings from the roundtables, as well as other research and interviews, to produce this policy brief to inform policymakers, industry, and other stakeholders on our major conclusions and their policy implications.

This policy brief is organized as follows:

- **Chapter 2: Policy Objectives** – summarizes the varying motivations behind energy policy in each country.
- **Chapter 3: Common Themes** – examines four common themes in the transformation of the electricity sector: the feed-in-tariff; transmission and grid challenges; economic and market impacts, and; fossil fuels and CO_2 emissions.
- **Chapter 4: Unique Themes** – assesses two issues unique to Germany and Japan: regional integration challenges and restructuring of the industry, respectively.
- **Chapter 5: Lessons** – presents key findings and lessons from the German and Japanese experiences.
- **Chapter 6: Implications for the United States** – discusses the implications and relevance of Germany and Japan's experience to date for U.S. policymakers.

[13] Throughout this policy brief, we specify those comments and information provided in private meetings or events.

2. Policy Objectives

For policymakers in any country, designing and implementing energy policy is a constant balancing act among three broad objectives: energy security, economic outcomes, and environmental protection. Since the oil shocks of the 1970s, energy policy has had a security component with the goal of reducing dependence on imported energy, thereby limiting vulnerability to supply disruptions, price volatility, and trade imbalances. Economic goals are also often embedded in energy policy with policymakers drafting energy laws and regulations to ensure low prices for consumers, spur growth, create jobs, raise revenue, or promote the creation of new industries.

Finally, energy policy also seeks to achieve environmental objectives: mitigating the adverse impacts of energy production and use, and especially in recent years reducing greenhouse gas (GHG) emissions to combat climate change. These objectives are not mutually exclusive: while one or the other may be the main driver, governments typically attempt to address all three. Significantly balancing these objectives is a complex endeavor: Goals may change over time and, although there is considerable linkage among them, they often conflict with one another.

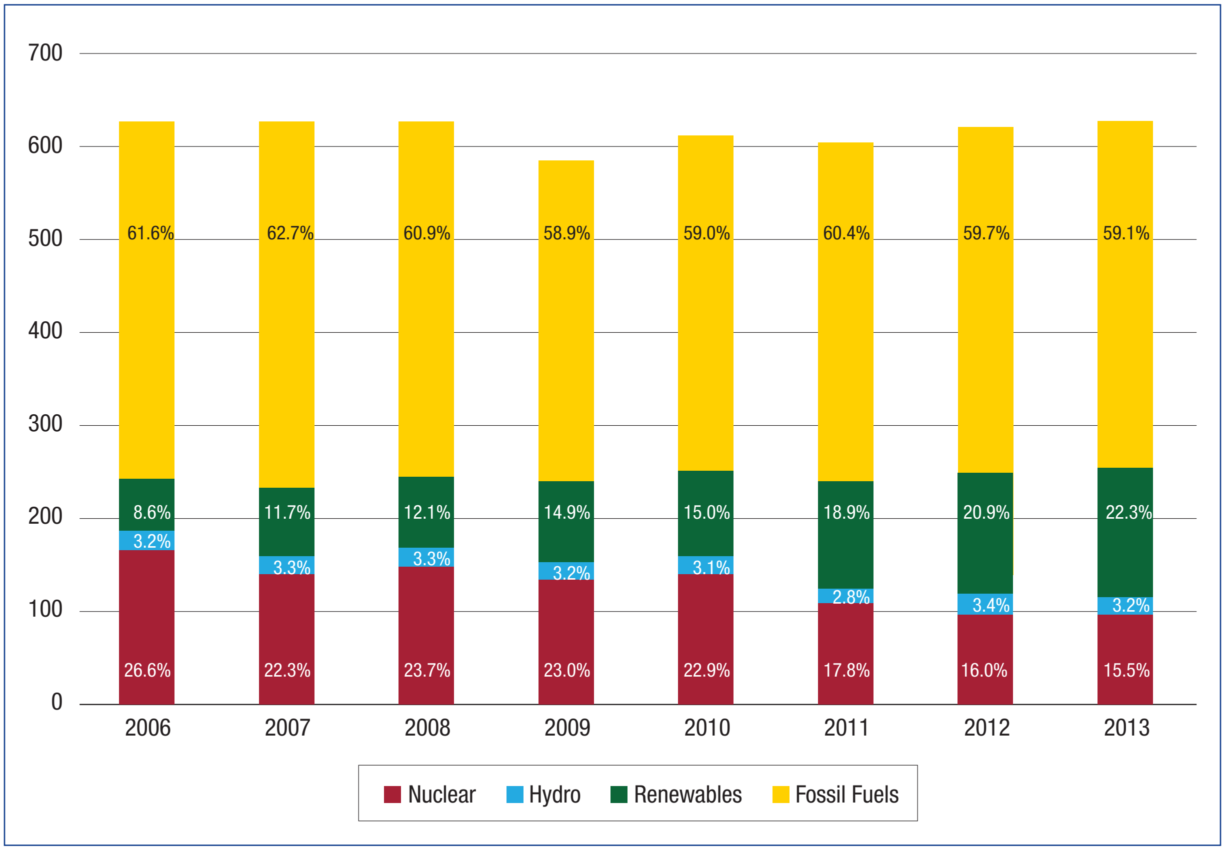
GERMANY

For more than two decades, environmental objectives have been a cornerstone of Germany's overall energy policy with the country committing to specific steps to address global climate change.[14] Germany ratified the Kyoto Protocol pledging to meet the emission reduction target established for Annex 1 countries, and adopted the EU's 1997 Directive on Renewable Energy Sources calling for renewables to reach 12 percent of electricity generation by 2010 (see **Exhibit 1**). Germany also committed to implementing the EU's 2020 Climate and Energy Package, adopted in 2007 and enacted in 2009, calling for the following achievements by 2020: a 20 percent reduction in EU greenhouse gas emissions from 1990 levels; raising the share of EU energy consumption produced from renewable resources to 20 percent and; a 20 percent improvement in the EU's energy efficiency.[15]

[14] Germany is also keen to reduce its imports of fossil fuels and the attendant economic impact on the economy and consumers. For example, the cost of imports of primary energy sources increased from €46 billion in 2000 to €89 in 2011 (see "Germany's new energy policy," Federal Ministry of Economics and Technology, Federal Republic of Germany, April 2012, 10).

[15] "The 2020 climate and energy package," European Commission, 21 May 2014, http://ec.europa.eu/clima/policies/package/.

Exhibit 1: Germany – Net Electricity Generation by Source 2006-2013 (TWh)



Source: Compiled from IEA, *Energy Balances of OECD Countries*, (2008), (2010), (2012), and (2014). Figures for 2013 are preliminary estimates.

Domestically, there is widespread consensus across the spectrum of political parties and among the general public to moving away from nuclear power while dramatically increasing renewable energy in the electricity mix. Specifically, the government has garnered widespread support for an aggressive, targeted national policy for renewable deployment. This support has been built incrementally beginning with the introduction of the Electricity Feed-In Law of 1990 (StrEG), and was followed by the Renewable Energy Law of 2000 (EEG), mandating the purchase of renewable electricity generation by grid operators and offering financial incentives to renewable power producers.

While phasing out nuclear power may seem at odds with climate change goals since nuclear power emits no GHGs, environmental concerns involving safety and spent fuel have spurred strong and vocal opposition to nuclear power, largely because of the Chernobyl accident, but also owing to other factors predating this event.[16] This attitude toward nuclear power was addressed formally in policy after the Social Democratic and Green party coalition came to power in 1998 and the government began developing a formal plan to phase out nuclear power. In 2002, the government and utilities agreed to shutdown nuclear reactors as they age, with a complete shutdown

[16] Alexander Glaser, "From Brokdorf to Fukushima: The long journey to nuclear phase-out," *Bulletin of the Atomic Scientists*, vol. 68, no. 6, November 2012, 10–21.

scheduled for 2022. However, in 2010, Chancellor Angela Merkel's new government chose to slow the phase-out policy, extending the operating life of existing reactors by an average of 12 years.[17]

The Energy Concept and the Impact of Fukushima

In 2010, the government adopted the *Energy Concept*, a detailed, "long-term overall strategy…up to the year 2050" in which "Germany is to become one of the most energy efficient and greenest economies in the world while enjoying competitive energy prices and a high level of prosperity" (see **Box 1**).[18]

The *Energy Concept* establishes the continued expansion of renewable energy as a lynchpin of climate and energy policy, but recognizes the need to control costs, spur innovation, and establish more market-oriented policies. In addition, expansion of renewable capacity must be accompanied by greater "qualitative and quantitative expansion of electricity grids" and promotion of storage technologies. The *Energy Concept* calls nuclear energy a "bridging technology" and states that a more flexible fleet of coal- and gas-fired power stations is required.[19]

On the heels of the *Energy Concept,* the accident at Fukushima led to changes in German energy policy. Chancellor Merkel reacted quickly ordering the inspection of all nuclear reactors and a moratorium on the operation of the seven oldest nuclear power plants (the eighth was already out of production due to technical issues). She also established two expert commissions tasking them to conduct separate reviews to reconsider nuclear energy policy.[20] At the end of May 2011, the Chancellor transformed the temporary shutdown of the eight oldest reactors to a permanent shutdown by the end of 2011. Germany's remaining nine reactors are to be phased out by 2022. Thus, by 2022, 23 percent of Germany's non carbon-emitting, existing generation will be removed from its electricity portfolio.

The decision was met with substantial support across political lines: the new policy was supported by 85 percent of parliamentarians, with the vote in the lower house an overwhelming 513-79

BOX 1

Germany's Energy Concept Targets

Emissions: Reduce GHGs compared with 1990 levels:

- 40 percent by 2020
- 55 percent by 2030
- 70 percent by 2040
- 80 to 95percent by 2050

Renewables: Increase the share of renewables in final energy consumption to:

- 18 percent by 2020
- 30 percent by 2030
- 45 percent by 2040
- 60 percent by 2050.

Energy efficiency: Reduce primary energy consumption compared with 2008:

- 20 percent by 2020
- 50 percent by 2050

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[17] IEA, "Energy Policies of IEA Countries: Germany 2013 Review," 2013, 9.

[18] BMWi, "Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply," Federal Ministry for Economics and Technology (BMWi), Federal Republic of Germany, 28 September 2010, p. 3, www.germany.info/contentblob/3043402/Daten/1097719/BMUBMWi_Energy_Concept_DD.pdf. The "Energy Concept" built on the government's *Integrated Energy and Climate Program* adopted in 2007, which outlined 29 measures to meet GHG emission reduction and renewable energy deployment targets (see IEA, "Germany 2013, 25-26).

[19] BMWi, "Energy Concept," 16.

[20] The Reactor Safety Commission and the Ethics Commission.

in favor.[21] The utilities and industry generally, however, were critical; Jürgen Grossmann, chief executive officer at the time of one of Germany's largest electricity suppliers, RWE, criticized the policy, stating: "Germany, in a very rash decision, decided to experiment on ourselves."[22] Chemical giant Bayer cautioned that it might have to relocate production facilities to other countries with "lower energy costs."[23]

Energy Package

On June 6, 2011, the government adopted *The Energy Package of 2011* amending the *Energy Concept* in light of the revised nuclear policy. Through the implementation of seven acts and one ordinance, the *Energy Package* emphasizes an "upgraded electricity grid infrastructure, a flexible electricity system, growing renewable energies, increased energy efficiency, and greater investment in research and development, notably in storage technologies."[24]

JAPAN

As a country nearly completely dependent on imports of fossil fuels for all its energy needs at the time of the oil shocks in the 1970s, Japan saw nuclear energy as an important means to alleviate this dangerous and costly energy import dependence and to power its export-driven economy. In 1974, the U.S. Department of Energy decided to discontinue providing enriched uranium to foreign buyers owing to concerns about a potential shortage of global enrichment services. At this point, Japan decided to embark on a program to close the nuclear fuel cycle by developing its own uranium enrichment and reprocessing capabilities, further propelling domestic investment into its nuclear industry.

The concept of energy security thus has become the central driver in Japan's energy policy.[25] The nuclear power industry was built up as such, allowing Japan to reduce its energy import dependence in the decades following the 1973 oil crisis. The disaster at Fukushima, however, prompted the government to reassess its nuclear power policy. In September 2012, the Energy and Environment Council published the "Revolutionary Energy and Environment Strategy," recommending a phase-out of nuclear power by 2040 (the "zero option").[26] The Japanese business community was strongly opposed: the Keidanren called it "unrealistic and unreachable," while the Federation of Electric Power Companies of Japan opposed the plan, saying it would have "a serious and immediate impact on Japan's electricity supply."[27] As a result, the cabinet refused to endorse the policy recommendation and dropped references to the timeline for a nuclear phase out, saying only that it would "take the report's recommendations into consideration."[28] The "zero option" was abandoned formally when Prime Minister Shinzo Abe came back into power in December 2012. The prime minister called for restarting some nuclear power plants, a policy supported by his Liberal Democratic Party, which

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[21] "Nuclear Power in Germany," World Nuclear Association, http://www.world-nuclear.org/info/country-profiles/countries-g-n/germany/.
[22] Elizabeth Rosenthal, "Germany dims nuclear plants, but hopes to keep lights on," *New York Times*, 29 August 2011.
[23] Ruby Russell, "Bayer threatens to quit Germany over nuclear shutdown," *The Guardian*, 7 August 2011.
[24] IEA, "Germany 2013 Review," 2013, 31.
[25] In addition, climate change emerged as an important factor in energy policymaking in 1990s.
[26] The government also agreed to abide by the three principles proposed by the ruling DPJ party: no new build of nuclear plants, strict application of a maximum of 40-year lifetime (with 20-year extensions granted in some exceptions) and the restart only for reactors that get approval from the nuclear regulatory commission.
[27] Martin LaMonica, "Japan approves nuclear phase-out by 2040," *MIT Technology Review*, 14 September 2012, http://www.technologyreview.com/view/429227/japan-approves-nuclear-phase-out-by-2040/.
[28] Mari Yamaguchi, "Japan Nuclear Phase-Out Plan Falls Apart," *The Huffington Post*, 19 September 2012, http://www.huffingtonpost.com/2012/09/20/japan-nuclear-phase-out_n_1897452.html.

won back the majority of both houses in the Diet in the summer of 2013.

The shutdown of all nuclear reactors highlighted the extreme vulnerability of Japan's economy in the absence of nuclear power. Japanese officials are focused on the dramatic increase in fossil fuel (LNG, oil, and coal) imports needed to replace nuclear power capacity and the attendant detrimental economic impacts. In fiscal year 2011, the country posted its first trade deficit in more than three decades, owing in large part to the combined effects of increased imports of LNG, coal, and oil and reduced industrial exports as the result of higher domestic energy prices.[29] This trend is threatening to reverse Japan's energy security progress since the 1970s. For example, at the time of the 1973 oil crisis, Japan relied on imports of fossil fuels for 76 percent of all fuels used in the power sector. By 2010, just prior to the Fukushima accident, this dependency had been reduced to 60 percent. Then, in 2012, reliance on imported fossil fuels for electricity generation increased to 88 percent, higher even than 1973 levels. From 2010 to 2012, the largest increases in exports were in LNG and oil products.[30]

> ***"Self-sufficiency is important, but having a stable supply of [energy] is another facet of energy security."***
>
> Japanese energy official, on renewable energy

The government is also increasingly concerned about the origin of fossil fuel imports and vulnerabilities to physical supply interruptions. In 2012, 83 percent of all crude oil procurement came from the Middle East. In addition, 80 percent passes through the Strait of Hormuz and 83 percent via the Straits of Malacca. LNG is also sourced from areas of geopolitical tension, although the levels of dependency are not as high. Japan imports 29 percent of its LNG from the Middle East, with 24 percent passing through Hormuz and 34 percent via Malacca.[31] Furthermore, tensions with China over sovereignty in the South and East China Seas add to Japan's concerns over expanding energy imports through these strategic chokepoints.

As a result of these issues, the Japanese government has begun to reemphasize energy security, in particular the guiding principle of "diversification" to address the negative macroeconomic impacts caused by large increases in imports of fossil fuels to meet the gap caused by the nuclear shutdown. As part of this approach, the government is accelerating efforts to increase the penetration of renewable energy, with officials noting that diversification achieved by deploying more renewable energy capacity enhances energy security. Major policy support for renewable energy has been in place for over a decade; as early as 2003, the government initiated a renewable portfolio standard, followed in 2009 by a program requiring utilities to purchase surplus electricity from small solar PV systems at fixed, long-term rates.[32] The latter policy has been particularly successful in stimulating a well-developed rooftop solar industry. In 2009, the government began discussions to establish a national feed-in-tariff, which finally took effect in 2012 (see chapter 3).

The government also initiated a broad examination and revision of national energy policy culminating

[29] The Japanese fiscal year begins April 1st.
[30] The figures in this paragraph were provided to Brookings by the Japanese government in December 2013.
[31] Ibid.
[32] See: Government of Japan, "Outline of the RPS System in Japan," http://www.rps.go.jp/RPS/contents/pdf/outline.pdf. Also: "Renewable Energy Attractiveness Indices," Ernst & Young, November 2010.

with the release of the "Basic Energy Plan" in early 2014. One of the plan's cornerstones is the clear indication that nuclear power will be part of the electricity mix moving forward, although "dependency on nuclear power generation will be lowered to the extent possible."[33] Indeed, two reactors at Kyushu passed the new safety standards and are expected to be restarted in the fall 2014.[34]

Nevertheless, opposition to any use of nuclear power remains fierce among a large portion of the Japanese public, making debate over the scale and the pace of a nuclear restart of any plants extremely contentious. In an attempt to assuage public anger, the government, despite its support of some use of nuclear power in the future, has stated it does not yet have targets for nuclear energy's share in the energy mix.[35] While political parties and industry continue to debate the extent of nuclear power to be brought back online, nuclear generation is unlikely to return to its pre-Fukushima levels. A mixture of renewables, fossil fuels, and demand-side management will inevitably play a significant role in replacing a large share of nuclear power.

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[33] METI, 4th *Strategic Energy Plan*, Government of Japan, April 2014, 24.

[34] Toshio Kawada, "Kyushu plant reactors first to meet new safety standards; to restart in fall," *Asahi Shimbun*, 16 July 2014.

[35] See "The Road Ahead for Japanese Energy," Brookings Institution public event, Washington, D.C., 12 June 2014, http://www.brookings.edu/events/2014/06/12-road-ahead-japanese-energy.

3. Common Themes

In ESI's discussions with stakeholders in Germany and Japan, four common themes emerged: a renewable policy approach centered on the feed-in-tariff, transmission and grid challenges, economic and market impacts, and rising fossil fuel use and CO_2 emissions.

Feed-in-Tariff

One of the major barriers for deploying renewable energy is cost: renewable technologies generally have high up-front capital costs, but lower operations and maintenance (O&M) costs and zero fuel costs.[36] For this reason, many policies in support of renewable energy focus on ways to overcome initially high capital expenditures in order to foster the commercial deployment of the technologies and bring down overall costs. The feed-in-tariff (FIT) is viewed as very effective in providing a guaranteed long-term revenue stream to overcome high initial capital costs and, along with priority dispatch, is critical in spurring the addition of large amounts of renewable capacity.

While there are variations, generally a FIT provides a guaranteed price—usually a premium above market levels—and grid access for power generated from a renewable energy source over a fixed, long-term period (e.g. 20 years). It is by far the most common policy tool used to promote renewable energy worldwide: globally, FITs account for 87 percent of all solar capacity and 64 percent of all wind capacity deployed.[37] FITs are the primary policy tool used in both Germany and Japan to promote renewable energy in the electricity sector.

Germany

For over two decades, German policy has supported renewable energy, largely utilizing the FIT (see **Exhibit 2** for a summary of FIT policy implementation). The first FIT was introduced in 1990 through the *Stromeinspeisungsgesetz* (StrEG). This policy was administered regionally with the FIT set at 90 percent of the retail electricity rate, ranging from €8.45 to €8.84 cent/kWh, with volume caps established according to utility service area.[38] The StrEG promoted some deployment of renewable energy, but was not sufficient to stimulate significant investment.

With the introduction of the *Erneuerbare-Energien-Gesetz* (EEG) in 2000—the Renewable Energy

[36] "Distributed Generation Renewable Energy Estimate of Costs," National Renewable Energy Laboratory (NREL), August 2013, http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html.

[37] Christine Lins, "The UNEP Feed-in Tariffs report: Policy Toolkit and Law Drafter's Guide," International Renewable Energy Agency (IRENA) Renewable Energy Workshop, Abu Dhabi, United Arab Emirates, 12 January 2013, 7.

[38] Mark Fulton and Nils Mellquist, "The German feed-in tariff for PV: Managing volume success with price response," Deutsche Bank Climate Change Advisors, 23 May 2011, 15.

Sources Act—Germany instituted a national FIT for the first time. The EEG provides for priority connection to the grid and purchase of renewable sources of power at a fixed premium. Tariff levels are embedded in law and are calculated based on the type of renewable energy source and the generation capacity of the installations. They are intended to decline annually by a predetermined degression rate to account for the decreased costs of installations and to encourage technological innovation over time.[39] Renewable power is purchased by the four transmission system operators (TSOs) and then sold at a wholesale rate on the European Energy Exchange (EEX) in Leipzig, Germany.[40] The difference between the wholesale price and the FIT is passed along as a surcharge—called the EEG-Umlage—on retail customers' bills. The 2014 surcharge per household is €6.24ct/kWh.[41]

There is a separate approach for large consumers and energy-intensive industries. Those entities with electricity consumption greater than 10 GWh annually pay the full surcharge on only 10 percent of their energy use and a reduced surcharge on the balance (€0.0005/kWh).[42] Energy intensive enterprises—with more than 100 GWh of total consumption and whose electricity costs are greater than 20 percent of their total costs—pay the lower surcharge on all consumption.[43]

The FIT in Germany has successfully stimulated greater renewable energy deployment with electricity generation from renewables increasing from 19 TWh in 1990 to 142 TWh in 2012 (see **Exhibit 2**). As noted, renewables now account for 23 percent of electricity consumption with even higher targets of renewable penetration set for the future (see below).[44]

The EEG has been revised several times since 2000. During the first phase (2000-2009), tariff adjustments were made annually with modest degression rates. In 2009, solar PV costs declined significantly, prompting the government to attempt to manage the number of PV installations coming on line each year through more rigorous and frequent degression adjustments. The third phase began in 2012 when further declining costs of renewable energy production made PV, wind, and biomass more competitive with traditional power generation.

One of the key components of the 2012 revisions was the introduction of a voluntary market premium model. Under this approach, renewable power plant operators can choose not to be paid the fixed FIT but sell electricity directly into the wholesale market. They receive revenue for the kWh sold, as well as a market premium.[45] The intent was to encourage producers to engage in more market-based behavior such as forecasting production, bidding planned production into the wholesale market, and balancing scheduled delivery with actual production. The structure of the payment incentivizes renewable producers to sell

[39] "Degression rate" refers to a design feature in FIT schemes whereby the premium paid for renewable energy produced is decreased automatically by a certain percentage periodically according to some metric, such as cost reduction of the renewable technology, capacity deployed, etc.

[40] This mechanism via the EEX was introduced in 2009. Between 2000 and end of 2008, renewable electricity was delivered to electricity suppliers and then to final consumers. Suppliers were required to take a monthly set volume of renewable electricity into its portfolio, paying an average renewable electricity price to the TSO. With a growing share of renewable electricity in their portfolios—which was fixed only a month ahead—suppliers faced an increasing volume risk and urged the new procedure via the EEX. Also, the day-ahead market is organized at the European Power Exchange (EPEX) in Paris. Thanks to Clemens Cremer for this background.

[41] See "EEG-Umlage 2014," http://www.netztransparenz.de/de/EEG-Umlage.htm.

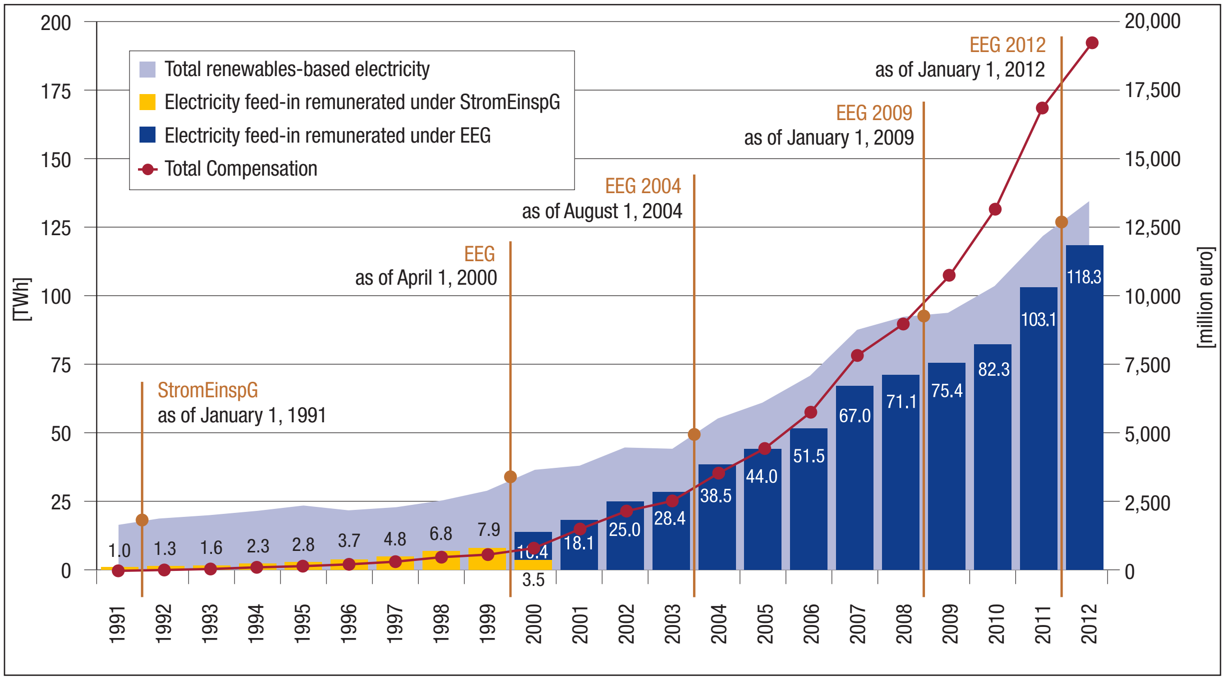
[42] "Energy Policies of IEA Countries: Germany 2013 Review," IEA, 2013, 12.

[43] Ibid.

[44] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), *Renewable Energy Sources in Figures: National and International Development*, Federal Republic of Germany, July 2013, 18.

[45] IEA, "Germany 2013 Review," 129. The market premium is the difference between the average wholesale price on the energy exchange and the FIT for the specific renewable technology; the management premium of €0.012/kWh covers administrative costs of using the energy exchange.

Exhibit 2: Feed-in and Fees under the Electricity Feed Act (StromEinspG) since 1991 and the Renewable Energy Sources Act (EEG) since 1 April 2000



Source: Renewable Energy Sources in Figures: National and International Development, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), July 2013, 36. See document for BMU's citation of specific sources.

when wholesale prices are higher and to curtail production at times of low prices.[46]

Concerns over the increasing costs of the EEG have prompted revisions to German policy—the so-called EEG 2.0—which became effective August 1, 2014. The following are the key elements of the law's most recent revisions:[47]

- Renewable energy targets: Renewable energy will account for 40 percent to 45 percent of electricity supply by 2025 and 55 percent to 60 percent by 2035 (the EEG reforms of 2012 had targeted 35 percent renewables by 2020; the new law does not have targets for 2020)
- Cost cuts: reduces the average financial support across all eligible renewable technologies from €17ct/kWh to €12ct/kWh by 2015
- Corridors: ranges of annual capacity additions allowed for certain renewable plants; for example onshore wind and solar PV growth will be capped at 2,500 MW per year, while offshore wind and biomass are capped at 6,500 MW and 100 MW annually by 2020, respectively

[46] The market premium incentivizes curtailment of renewable production when the wholesale price drops below the negative value of the market premium. One utility official estimated that wind power producers have an incentive to cut production at about -60 €/MWh, but "this is a considerable improvement to the situation when the TSO had to buy all renewable electricity and bring it to the market irrespective of the actual demand and resulting price."

[47] BMWi, "Key elements of a revised Renewable Energy Sources Act," Federal Ministry of Economics and Technology, Federal Republic of Germany, Berlin, 21 January 2014, http://www.bmwi.de/English/Redaktion/Pdf/eeg-reform-eckpunkte-english,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf. See also: Matthias Lang, "EEG 2.0: Further information on key points of reform of German renewables law," *German Energy Blog*, 24 January 2014, http://www.germanenergyblog.de/?p=15159. Revisions to industry exemptions from the EEG surcharge are also proposed and discussed later in this brief.

- Breathing caps: ranges of financial support for new capacity that increase or decrease depending on capacity growth

- Mandatory direct marketing: the FIT will be phased out and instead renewable plant operators will be required to sell directly into the market under a market premium model described above (currently this system is voluntary)

- Auctioning: By 2017, a tendering system will be introduced in which BNetzA organizes a process to solicit renewable capacity additions (replacing the system of mandatory offtake); this will start with a pilot project for a 400 MW freestanding solar power plant

- Self-generation and self-consumed power exemptions: some new renewable plants for self-generation and consumption will now have to pay a portion of the EEG surcharge[48]

The system of exemptions for large industries is also under fire. First, the policy has cushioned larger energy intensive industries from the EEG surcharge while individual households bear a growing financial burden (this is described in more detail later in this chapter). Second, the EU is challenging the system, arguing that the exemptions constitute state support for particular industries, providing an unfair competitive advantage to those firms not paying the surcharge. However, the German government does not consider the industry exemptions as state-sponsored support.

The German government and the EU have reached agreement to resolve the EU's concerns over industry exemptions from the EEG surcharge. Under the agreement, Germany will continue to offer exemptions but to a reduced number of companies: 1,600 as opposed to 2,100. Companies will be required to pay 15 percent of the overall levies supporting renewable energy, although the levies for energy intensive firms are capped at 0.5 percent of gross added value.[49] These changes, along with others contained in the EEG 2.0, could result in a decrease in the EEG surcharge.[50]

The intent of all these changes described above is to make the policy more market-oriented and to control costs and capacity growth.

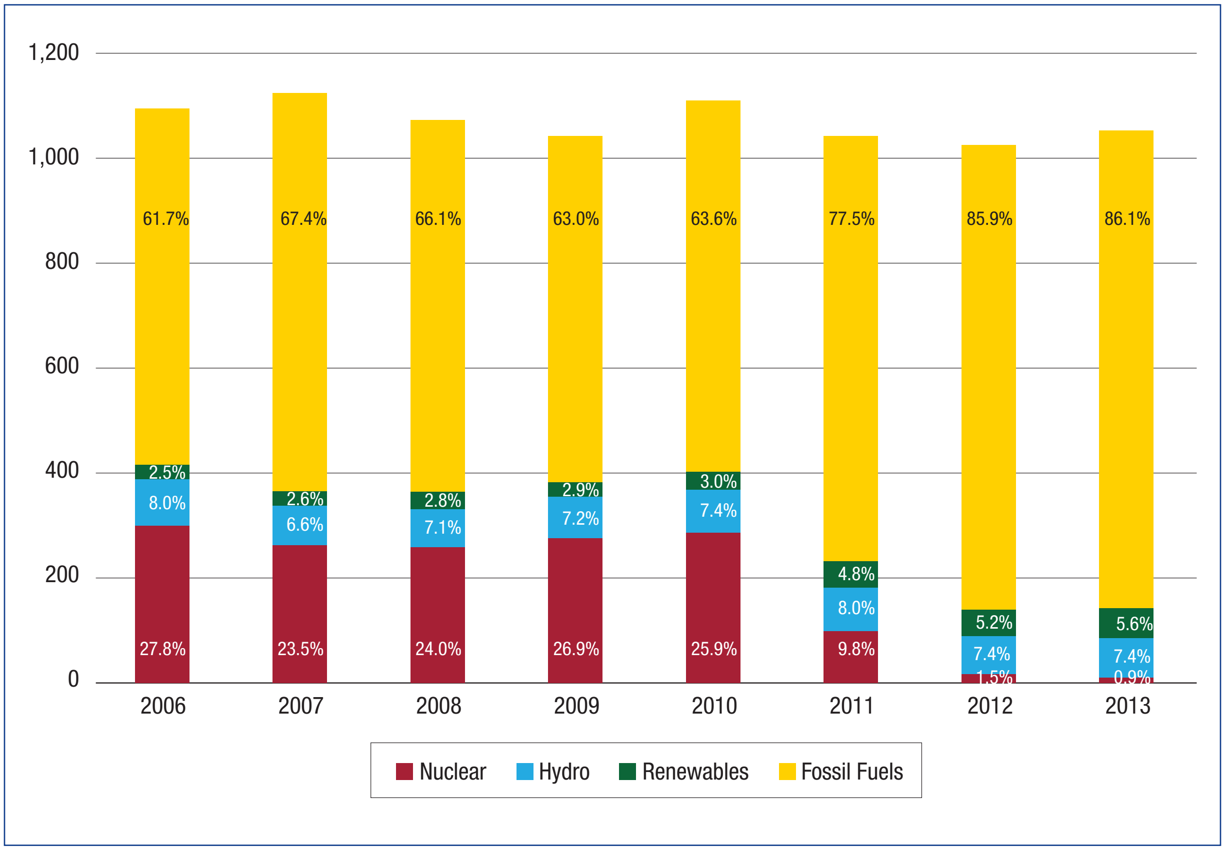
Japan

Launched in July 2012, the FIT policy was one of several pieces of legislation requested by the prime minister at the time, Naoto Kan, and remains the most significant policy promoting renewable energy development in Japan.[51] Kan introduced this policy as part of his efforts to push Japan to target a renewable proportion of 20 percent of its energy mix by the 2020s. Currently, non-hydro renewables account for about 1 percent of total electricity generation (see **Exhibit 3**).

The tariff in Japan requires the utilities to purchase electricity from renewable sources at fixed prices for set periods of time (see **Table 1**). The Ministry of Economy, Trade, and Industry (METI) determines the price and contract period for feed-in-tariffs, which are paid via a surcharge on consumers that equates to a national average of ¥0.40 per kWh.[52] The government estimates that for FY2013, a typical household (consumption of 300

[48] Lang, "EEG 2.0," January 2014. Existing power plants continue to be exempt from the EEG surcharge; new and old power plants with a capacity of up to 10 kW are exempt from EEG surcharge for up to 10 MWh annually; new power plants pay 90 percent of the EEG surcharge of €6.24 ct/kWh in 2014; certain renewable power plant operators (CHP plants and process-related cogeneration gases) pay 70 percent of the EEG surcharge.
[49] Jeevan Vasagar, "Berlin secures energy concessions from EU," *Financial Times*, 8 April 2014.
[50] For example, see the analysis in "Proposal for a Revision of the Industry Exemption rules under the German EEG," Agora Energiewende, January 2014.
[51] See: METI, *Feed-in-Tariff Scheme in Japan*, Government of Japan, http://www.meti.go.jp/english/policy/energy_environment/renewable/pdf/summary201207.pdf. Also: Chico Harlan, "In Japan, new policy spurs solar power boom," *The Washington Post*, 4 June 2013, http://articles.washingtonpost.com/2013-06-04/world/39723876_1_feed-in-tariff-nuclear-power-solar-power.
[52] Private meeting, ANRE-METI, 18 February 2014.

Exhibit 3: Japan – Net Electricity Generation by Source 2006-2013 (TWh)



Source: Compiled from IEA, *Energy Balances of OECD Countries*, (2008), (2010), (2012), and (2014). Figures for 2013 are preliminary estimates.

kWh/month) paid ¥120/month for the tariff.[53] According to METI, renewable energy capacity has grown 43 percent since the FIT was introduced, with solar energy accounting for nearly all of that capacity (see **Table 2**). As a result, the tariff for solar power was lowered for FY2013, while rates for all other forms of electricity remained the same (see **Table 3**). METI has cited the lower cost of solar projects as the primary reason behind the lowered purchase price.[54]

Japanese solar manufacturers are rushing to meet booming demand for solar modules, but demand for solar capacity far exceeds domestic production. According to the Japanese Photovoltaic Energy Association, 1,653,874 kW of solar modules were shipped for Japanese use in Q1 2013, but more than half of those (924,956 kW) were imported.[55]

[53] "Japanese Feed-In Tariff Updates," Cleantechnica, 30 March 2013, http://k.lenz.name/LB/?p=9132. The cost in FY2012 was ¥0.29 per kWh, or ¥87/month (approximately $.85): see METI, "Settlement of FY2013 Purchase Prices for Newcomers and FY2013 Surcharge Rates under the Feed-in Tariff Scheme for Renewable Energy," Ministry of Economy, Trade and Industry, Government of Japan, 29 March 2013, http://www.meti.go.jp/english/press/2013/0329_01.html.

[54] Ibid.

[55] Herman K. Trabish, "Japan's Solar Market Surge Blows Away Earlier Forecasts," *GreenTechMedia,* 7 November 2013, http://www.greentechmedia.com/articles/read/Japans-Solar-Market-Surge-Blows-Away-Earlier-Forecasts. Japanese PV manufacturers have module production facilities in other countries in the region, so imports also represent the regionalization of production by Japanese firms (thanks to Llewelyn Hughes for highlighting this point).

Table 1: Japan's Feed-in-Tariff

Source	Purchase Price per kWh w/o Tax (FY2012)	Purchase Period in years
Solar (10kW or more)	40 Yen	20
Solar (Less than 10kW)	42 Yen	10
Wind (20kW or over)	22 Yen	20
Wind (Less than 20kW)	55 Yen	20
Hydro (1,000 kW – 3,000 kW)	24 Yen	20
Geothermal (15,000 kW or more)	26 Yen	15
Geothermal (less than 15,000 kW)	40 Yen	15
Biomass (methane)	39 Yen	20
Biomass (trees/bamboo)	32 Yen	20
Biomass (wood/crops)	24 Yen	20
Waste Construction Materials	13 Yen	20
General Waste	17 Yen	20

Source: "Japan Launches the Feed-in Tariff System for Renewable Energy," Jones Day, July 2012, http://www.jonesday.com/japan_launches_feed-in_tariff_system/.

Table 2: Status of Renewable Energy Generating Capacity in Japan

	BEFORE INTRODUCING FIT	AFTER INTRODUCING FIT	
Renewable Energy Generating Facilities (type of source)	Combined Total Capacity of Facilities before July 1, 2012	Combined Total Capacity of Facilities in FY 2012	Combined Total Capacity of Facilities in FY 2013
Photovoltaic power (for households)	About 4,700,000 kW	969,000 kW	1,307,000 kW
Photovoltaic power (other than households)	About 900,000 kW	704,000 kW	5,735,000 kW
Wind power	About 2,600,000 kW	63,000 kW	47,000 kW
Small and medium hydropower	About 9,600,000 kW	2,000 kW	4,000 kW
Biomass power	About 2,300,000 kW	30,000 kW*	92,000 kW
Geothermal power	About 500,000 kW	1,000 kW	0 kW
TOTAL	**About 20,600,000 kW**	**1,769,000 kW**	**7,185,000 kW**
		8,954,000 kW	

Source: "Announcement Regarding the Present Status of Introduction of Facilities Generating Renewable Energy as of March 31, 2014," METI, http://www.meti.go.jp/english/press/2014/0617_02.html. Fiscal years run from July 1 to March 31.

Table 3: Solar FIT Rates in Japan (FY2012 and FY2013)

	FY2012	FY2013
Non-Household Customers (<10kW)		
Price per 1kWh (excluding tax)	40 Yen	36 Yen
Price per 1kWh (including tax)	42 Yen	37.8 Yen
Household Customers (>10kW)		
Price per 1kWh (excluding tax)	42 Yen	38 Yen

Source: Agency for Natural Resources and Energy. "Settlement of FY2013 Purchase Prices for Newcomers and FY2013 Surcharge Rates under the Feed-in Tariff Scheme for Renewable Energy," Ministry of Economy, Trade and Industry. http://www.meti.go.jp/english/press/2013/0329_01.htm

It is far too soon to opine on the effectiveness of the FIT in Japan and its long-term results will not become evident for years. The impact of the tariff scheme at this point is mixed. For instance, despite the tariff contributing to the tripling of independent power producers (IPPs) during the last two years, IPPs still make up less than 3 percent of the country's total power capacity.[56]

Japanese renewable energy policy confronts several challenges. First, the cost of solar deployment remains high: large scale solar costs $3 per watt while residential solar costs average $4 per watt.[57] Explanations for these high costs include a lengthy supply chain from modules to consumer (perhaps as many as three companies), and high financing costs since banks have just started to support these projects. A representative of a renewable energy company in Japan stressed that since there is a 100 percent reliance on project finance, small projects are hard to fund and therefore renewable energy policy should emphasize wind and geothermal projects (although the location of some of these resources will require greater investment in the grid). Other renewable energy supporters stated that while utility scale solar has dominated thus far, there is considerable opportunity for distributed solar capacity and battery storage.[58]

In addition, the lack of flat land limits the number of wind turbines constructed in any given area, keeping costs high.[59] Only 27 percent of Japan's territory is considered "flat" and thereby suitable for renewable energy deployment. In addition, land prices are generally high in Japan, offsetting the attractiveness of some renewable investments. These limitations also present challenges for constructing adequate additional transmission lines to transport wind power from major wind generating areas (such as the northern island of Hokkaido) to demand centers (such as Tokyo and Osaka).

Extensive environmental impact assessments are also required and can take more than five years for technologies requiring significant land use, such as wind, large-scale solar, and geothermal. The permitting process is easier for rooftop solar PV, partly explaining the large volume of solar projects (20 GW) in the pipeline.[60] However, experts estimate that only about 40 percent of all applications will be completed owing to the combination of factors described above.

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[56] David McNeill, "Japan pins hopes on increased use of solar power," *Financial Times*, 2 December 2013, http://www.ft.com/intl/cms/s/0/38f21a9c-5048-11e3-9f0d-00144feabdc0.html.
[57] Estimate provided by Japanese renewable expert at Brookings Tokyo Roundtable, December 2013.
[58] Private meeting. See also: "In Japan, new policy spurs solar boom," *Washington Post*, 5 June 2013.
[59] Private meeting, ANRE-METI, 18 February 2014.
[60] By way of comparison, the Japanese government estimates that there is potential for 5 GW of wind capacity by 2020. See: IEA Wind, "2012 Annual Report," IEA, 2012, https://www.ieawind.org/annual_reports_PDF/2012/Japan.pdf.

Grid connection is another costly obstacle in Japan, although this situation is being addressed in the recent deregulation plans for the power sector (see chapter 4). The FIT policy allows utilities discretion to deny access to the grid for reasons of stability.[61] The utilities also use a quota system to invite bids for wind power but with many applicants and a lottery system to select winning bids, there are many companies that do not get connected.[62]

In a private meeting, an official from the Agency for Natural Resources and Energy, a branch of METI, outlined how the government seeks to facilitate rapid adoption of more wind and geothermal capacity by streamlining the environmental assessment process and improving power distribution networks.[63] However, many electricity sector experts argue that, while these two areas are important components of building out renewables, other factors should be prioritized, including flexible pricing mechanisms and delineation of responsibility for management and operation of the transmission networks. Others cautioned that the government must think through carefully the ideal FIT that will allow it to reach its renewable energy targets while ensuring technological differentiation.

TRANSMISSION AND GRID CHALLENGES

Transmission expansion is critical to support renewable energy deployment. With renewable resources, especially wind, often located far from demand centers, it is necessary to enhance and expand the high voltage transmission network to connect supply with demand. However, there are several challenges to overcome. First, building transmission infrastructure is expensive.[64] Second, the permitting and siting of long-distance transmission lines often takes many years owing to competing jurisdictional oversight and local opposition. The result is that transmission expansion may not keep pace with renewable deployment, causing adverse impacts on the electricity market. Moreover, a variety of technical challenges must be anticipated and addressed related to operational integration of renewable energy, especially distributed generation. In short, policies designed to promote the addition of renewables in the electricity portfolio may not coincide with—or may outpace—policies and plans to enhance and expand the transmission grid, while ensuring operational integration. All of these issues are present in Germany and Japan.

Germany

Since 2005, transmission in Germany has been unbundled completely from generation. Four transmission system operators (TSOs) own, operate and maintain assets, serve as the system and market operator for their territory, and administer the EEG mechanism. In addition, the Federal Network Agency (*Bundesnetzagentur* or BNetzA) was created to regulate the national grid including ensuring open access to the market and the approval of network charges.[65]

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[61] See: "Japan's grid can support solar boom?" UPI, 15 August 2013, http://www.upi.com/Business_News/Energy-Resources/2013/08/15/Japans-grids-can-support-solar-boom/UPI-77991376591302/.

[62] Asahi Shimbun, 22 May 2013.

[63] Private meeting, ANRE-METI, 18 February 2014.

[64] Estimates vary, but one recent analysis pegged the cost of overhead transmission in the U.S., based on projects under development surveyed by the Brattle Group, in the range of $2 million to $6.6 million per mile depending on voltage (see *A Survey of Transmission Cost Allocation Issues, Methods and Practices*, PJM Interconnection LLC, 10 March 2010, 9). It should also be pointed out, however, that transmission costs are generally cheaper than generation capacity. For example, one study examining a scenario of 20 percent wind penetration by 2024 in the Eastern Interconnect of the United States estimated incremental transmission costs to be 2 percent of wholesale energy costs. See reference to the Joint Coordinated System Plan in Michael Milligan, Kevin Porter, Edgar DeMeo, Paul Denholm, Hannele Holttinen, Brendan Kirby, Nicholas Miller, Andrew Mills, Mark O'Malley, Matthew Schuerger, and Lennart Soder, "Wind Power Myths Debunked," *IEEE Power & Energy Magazine*, Institute of Electrical and Electronics Engineers (IEEE), November/December 2009, 89-99, http://www.ieee-pes.org/images/pdf/open-access-milligan.pdf.

[65] For utilities with less than 100,000 customers in only one state, the state regulatory offices have authority over the network.

The German government recognizes the critical importance of transmission and grid modernization to the success of the *Energiewende*. Indeed, steps to facilitate expansion of the high voltage grid to support increasing levels of renewables began before Fukushima and the decision to accelerate the nuclear phase-out. The German Energy Agency (DENA) concluded studies in 2005 and 2010 assessing grid requirements for higher levels of renewable energy.[66] Moreover, since 2009, the German government has enacted several key legislative instruments to support transmission expansion to meet more aggressive renewable energy targets, based especially on vast offshore wind production in the north (see **Box 2**). The bulk of the country's renewable energy is produced in the wind- and biomass-rich northern and eastern states while many of Germany's nuclear plants and industrial demand centers are located in the south. In particular, these new legal instruments were designed to resolve delays in transmission expansion caused by local opposition—including lengthy legal proceedings to halt transmission infrastructure construction—and by a planning process involving extensive discussions between federal authorities and the states (Länder) causing a transmission project to take an average of seven to10 years to construct.[67]

Drawing on DENA's grid studies, the Power Grid Expansion Act of 2009 established 24 specific projects totaling 1,834 km as "required," i.e. necessary and urgent to expand the transmission grid.[68] In

BOX 2

Key Transmission Legal Reforms in Germany

- Power Grid Expansion Act (2009, *Energieleitungsausbaugesetz* or EnLag): "The objective is is acceleration of the expansion of the transmission grids."
- Energy Concept (2010): "promises to transform energy supply—and provides a road map to a truly genuine 'renewable age.'"
- Grid Platform (March 2011): "Future-oriented grids' platform to take a joint approach in tackling open issues and deliver recommendations for action with regard to grid expansion, system stability and grid modernization."
- Grid Expansion Acceleration Law (August 2011, *Netzausbaubeschleunigungsgesetz* or NABEG): prescribes a package of measures to reduce the time required for planning and approval procedures for interstate or international very-high voltage lines."
- Energy Industry Act (Amended August 2011, *Energiewirtschaftsgesetz* or EnWG): "A framework policy to enhance competition, security of supply and sustainable energy production."

[66] For an overview of the first study see DENA, "DENA Grid Study I," http://www.dena.de/en/projects/renewables/dena-grid-study-i.html. Progress in meeting the recommendations of this study was slow: by the end of 2010 only 90 kilometers of the proposed 850 km had been built. The second DENA grid study, conducted to re-assess transmission needs in light of decisions to expand renewable energy targets, called for 3,600 km of additional routes in the transmission grid. See "Dena Grid Study II – Integration of Renewable Energy Sources in the German Power Supply System from 2015 – 2020 with an Outlook to 2025," http://www.dena.de/fileadmin/user_upload/Publikationen/Erneuerbare/Dokumente/Summary_dena_Grid_Study_II.pdf.

[67] Estimate from private interview.

[68] Katharina Schäfer, "Challenges and solutions in the expansion and modernization of the power grids in Germany," Ministry of Economy and Technology, Federal Republic of Germany, http://renewables-grid.eu/fileadmin/user_upload/Files_RGI/Katharina_Schaefer_German_Ministry_of_Economics_and_Technology.pdf.

addition, as part of the Energy Package of 2011, two legal reforms were enacted to address key challenges to expanding the transmission grid. First, the Grid Expansion Acceleration Law (NABEG) made BNetzA the main agency responsible for planning and approving inter-regional high voltage lines reducing the time required from over ten years to a target of four. This reform changed the approval process from a Länder-based to a federal-based system while centralizing the planning and approval process at the federal level. Second, the Energy Industry Act (EnWG) was amended, establishing the requirement for the four TSOs to develop a 10-year grid development plan, updated on an annual basis. After approval by BNetzA, it is submitted to the government in draft form under the provisions of the Federal Requirement Plan Act. The first Grid Development Plan, drafted in May 2012 and subsequently approved by BNetzA, called for enhancing 4,400 km of existing lines, the construction of 1,700 km of new alternating current power lines, and the building of 2,100 km of new direct current power lines at a total cost of €20 billion over 10 years.[69]

Thus, the legal framework established since 2009 requires the four TSOs to prepare periodic scenarios of the German energy sector leading to a network development plan that becomes part of the federal planning process. This process elevates the role of BNetzA, making it the central authority for any transmission line crossing state borders; expands and delineates the role for public participation; and establishes in law specific transmission projects to be built. Moreover, the legal framework establishes the Federal Administrative Court in Leipzig as the sole legal authority to rule on disputes involving transmission projects specified in the federal law.[70]

> ***"In Germany we did not synchronize renewable energy [deployment] with the build-up of necessary transmission lines."***
>
> German TSO Official

Despite these improvements, challenges remain. First, construction has been slow. BNetzA estimated in mid-2013 that only 15 percent, or 268 km, of the required transmission lines in the Power Grid Expansion Act had been built.[71] Transmission projects continue to face opposition from various states and at some local levels. For example, several parties in the state of Thuringia sued to halt a planned 380kV line, and the Bavarian government requested a moratorium on transmission construction pending an assessment of whether revisions to the EEG law will impact the need for the transmission expansion.[72] In short, "a central challenge is the need to convince people that more renewable energy requires more lines."[73]

To reduce opposition to the construction of new transmission lines, one interesting concept proposed by the government is to allow local communities and citizens along affected routes to invest in transmission projects. This approach is intended to achieve a level of buy-in to projects,

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[69] Private presentation from German TSO.

[70] Matthias Lang, "Bundesrat passes Federal Requirement Plan for transmission networks," German Energy Blog, 7 June 2013, http://www.germanenergyblog.de/?p=13250.

[71] After the Grid Development Plan was introduced in May 2012, one project was removed; see Matthias Lang, "Slight Progress in Construction of EnLAG Extra-High Voltage Power Line Projects," German Energy Blog, 13 December 2013, http://www.germanenergyblog.de/?p=14943).

[72] Matthias Lang, "Federal Administrative Court dismisses lawsuits against extra-high voltage line in Thuringia," *German Energy Blog*, 19 July 2013, http://www.germanenergyblog.de/?p=13746. See also: Matthias Lang "TSOs present proposal for major North-south power line project – need political support and postpone road shows," *German Energy Blog*, 6 February 2014, http://www.germanenergyblog.de/?p=15261.

[73] TSO official, private interview.

reducing public resistance. Parameters under discussion indicate that interested citizens or groups would be required to invest at least €1,000 and could earn a 5 percent return, although the TSOs are seeking to ensure that they will be able to recover any costs associated with implementing such a program.[74]

The TSOs also are intervening in the market more frequently, specifically to redispatch conventional power plants and curtail renewable generation. BNetzA estimated that curtailments rose from 39 in winter 2010-2011 to 197 in winter 2011-2012.[75] The cost of these interventions is estimated to be €70 million to €120 million annually and is added to network tariffs and passed along to final consumers.[76] However, fewer interventions occurred in the winter of 2012-2013 and steps are being taken to address capacity and stability issues. For example, an amendment to existing law was passed specifying that certain plants deemed "system-relevant" cannot be de-commissioned, and an ordinance was enacted specifying rules for a TSO to procure reserve power from existing plants through a competitive process.[77] Despite the interventions, associated costs, and need for market design adaptations, the German TSOs now view this situation as part of "normal operations," and that while "we are intervening in the market a lot more," the main challenge remains the lack of transmission capacity.[78]

In addition, several observers have cited a variety of technical challenges relating to "lack of coordination and planning in deploying distributed energy resources," such as impacts on distribution systems, lack of stabilizing inertia, and risk of mass disconnection of PV generation.[79] Efforts are underway examining how to better integrate renewable energy. For example, the issue of PV disconnection—the so-called 50.2 Hz problem—is being addressed in the grid code and through associated software changes at the plant level at an estimated cost of €300 million.[80]

Japan

Japanese stakeholders are also confronted by transmission challenges related to supporting the integration of larger volumes of variable renewable generation. In Japan's case, however, many experts and officials are concerned about how the government's proposed electricity market deregulation, which involves the creation of a new entity for Cross-regional Coordination of Transmission Operators, or OCCTO, will affect the expansion of renewable energy generation (these restructuring reforms are discussed in detail in chapter 4). The Japanese government has set an ambitious goal of establishing the OCCTO by 2015, moving to full retail competition of electricity by 2016, and to a fully unbundled transmission and distribution system by 2020. This complete dismantling of the existing vertically integrated utilities is no simple task, as noted by numerous experts, and challenges transmission planning. Such a transitional environment could create unforesee-

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[74] Matthias Lang, "BMU, BMWi and TSOs present key issues paper for citizen participation in power line projects," *German Energy Blog*, 8 July 2013, http://www.germanenergyblog.de/?p=13567. Tennet is the first TSO to undertake this approach, seeking to raise €40 million from private investors for a 380 kV West Coast power line; see Matthias Lang, "Possibility of Citizen Participation in Power Line Project," *German Energy Blog*, 13 January 2013, http://www.germanenergyblog.de/?p=12079.

[75] See Matthias Lang, "Bnetz report on tense electricity grid situation in winter 2011-2012," *German Energy Blog*, 8 May 2012, http://www.germanenergyblog.de/?p=9293.

[76] Estimate provided by TSO official in private interview.

[77] Mathias Lang, "Government passes ordinance on reserve power plants to ensure security of supply," *German Energy Blog*, 13 June 2013, http://www.germanenergyblog.de/?p=13296.

[78] Private interview.

[79] "The integrated grid: Realizing the full value of central and distributed energy resources," EPRI, February 2014, 13.

[80] Solar PV installations were initially designed to disconnect from the grid if frequency levels varied from 50 Hz to 50.2, presenting the challenge of managing a grid with mass PV disconnection. The €300 million figure is cited in the EPRI 2014 report and was also verified by a TSO official in a private interview.

able obstacles in addition to basic questions about how transmission functions will be carried out in an unbundled sector and who will undertake needed investments in the system.

These are familiar concerns representing challenges that every country faces during the reform process. In vertically integrated systems, key transmission functions are undertaken and coordinated within a single corporate entity. Once transmission functions are disaggregated among new, separate entities, there is a concern over who will be the system operator, who will be responsible for planning and investment, and who will be the market operator (settlement). In addition, trading arrangements—the operational, commercial, and legal rules governing how the new market functions—must be designed to replicate the results of the command and control approach inherent in a vertically integrated model.

These questions were highlighted in our discussions, particularly around the large wind resources on Hokkaido, the development of which is viewed as key to reaching the government's renewable energy targets. For example, suppose the direct current (DC) tie line between Hokkaido and Honshu lacks the ability to transfer power (the interconnection capacity with the Tohoku Electric Power system is 0.6 GW). The question arises: Will addressing this issue be the responsibility of the OCCTO, or of the unbundled Hokkaido Electric Power Company? This question triggers a broader debate over the role of the OCCTO for ensuring renewable energy integration.

The government's response at this point is that many of the details are still to be worked out. Officials stated that in the example given above, OCCTO would make the order and the decision to transfer power, while the Hokkaido Electric Power Company (and later an unbundled Hokkaido independent transmission operator) would be responsible for the investment. However, outside investors would necessarily be invited if Hokkaido lacks the financial resources.

In addition, sufficient reserves and capacity are critical for renewable energy integration, requiring an incentive to provide capacity and reserves to the system. Japanese stakeholders also emphasized that a robust ancillary services market is also necessary for renewable integration, as are "control and back-up capability, and frequency stability." In short, a key question is: Who is responsible for the stable supply of power? Without adequate consideration of how to coordinate the market and ensure that rules are in place, the Japanese government would be making a cardinal error if they do not address this question during the deregulation planning.

There are also concerns over who will undertake needed transmission investment in a de-regulated market, particularly in determining "transmission fee structures," and the public sector's role. Some argue that the government should bear the cost of an enhanced tie line to connect transmission in Hokkaido-Honshu in the interest of energy security, but note that, "the government is poor."[81]

U.S. utility executives participating in discussions with Japanese counterparts echo such concerns, stating that, while generation was the most successful part of deregulation in the United States, it is very difficult to take transmission systems designed for localized service and then stitch them together to work as a national network. It is thus important to ensure that key foundations including training and simulations are addressed ahead of time and that software is in place and upgraded.

[81] Comments in this paragraph are pulled from private interviews.

MARKET AND ECONOMIC IMPACTS

Our discussions with stakeholders in Germany and Japan indicated that the increasing penetration of renewables in the power sector and taking nuclear capacity offline are posing serious challenges for existing electricity markets and for the profitability and existing business model of incumbent utilities. In addition, there is growing concern that rapid transition to renewables is threatening broader economic competitiveness through rising electricity costs and greater system unreliability.

Germany

Electricity Market and Consumers

The growth in renewable generation is challenging the existing electricity market of the traditional utilities while confronting policymakers with a new set of challenges. With priority dispatch and near-zero operating costs, renewable technologies are driving down the marginal cost of power and thus wholesale electricity prices (the "merit order effect"). In 2008, wholesale electricity prices in Germany were €80/MWh but fell to €38/MWh in late 2013.[82]

> ***"The energy transition is destroying private capital and German policy has re-distributed wealth from poor to rich."***
>
> German utility official

With large fossil fuel generation fleets, the German utilities have been affected adversely by low wholesale prices: "large parts of fossil fuel capacity are obsolete [uncompetitive] in many hours of the year," and natural gas units are now "out of the money" while coal plants operate often, but at low margins.[83] In effect, the low marginal cost of renewable power generation is pushing coal prices to set electricity prices. A German utility representative stated that the declining profitability of conventional power plants is "a natural market reaction," while another utility executive more bluntly stated, "This market is cannibalizing gas and coal."[84]

There is concern among the utilities that current German energy policies are creating billions of dollars of stranded assets, without any real discussion about who pays when renewables do not meet demand and there is no back-up power for commercial and industrial activities. Low wholesale price levels are not enough to incentivize new investment, threatening the reliability of the whole system. One German utility official cited this trend indicating that market functionality is deteriorating and that the security of supply is not achieved with renewables—the market no longer delivers investments, so investments need to go to government-supported technologies.

Indeed, the impact has been severe with the large utilities losing an estimated €110 billion in market value since 2007.[85] In 2013, RWE, Germany's second largest utility, announced its first net loss (€2.3 billion) in 60 years while, since 2010, E.ON's income from fossil fuel and nuclear generation has dropped by more than one third.[86]

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[82] "How to lose a half a trillion euros: Europe's electricity providers face an existential threat," *The Economist*, 12 October 2013 , http://www.economist.com/news/briefing/21587782-europes-electricity-providers-face-existential-threat-how-lose-half-trillion-euros.
[83] Private comments from two German utilities.
[84] Private comments from German utility, June 2013.
[85] Market value estimate provided privately from German utility.
[86] *The Economist*, "How to lose half a trillion euros," October 2013; and "Germany's RWE slides into €2.8bn net loss for 2013," *Financial Times*, 4 March 2014.

There are several other dynamics having an impact on the market and existing utilities beyond the higher share of renewables in the electricity mix. Given the market conditions that existed in the early to mid-2000s, utilities overbuilt conventional fossil fuel facilities, banking on higher returns compared with renewable generation. However, changing EU carbon policies, the rise of shale gas in North America, and declining electricity demand after the onset of the 2008 financial crisis undermined the assumptions supporting those investment decisions (see below for more on these factors). In truth, the increase in renewable energy has exacerbated trends already in motion.[87]

Nevertheless, both supporters and critics of the *Energiewende* largely agree that it is now necessary to adapt market design to ensure sufficient investment and capacity, as well as to enable continued higher levels of renewables deployment.[88] However, this must be done in a way that does not destabilize the system or significantly raise costs for consumers. In short, the market now needs greater "flexibility" and ways to price that flexibility. Specifically, some experts and policymakers are debating whether Germany needs a capacity market (kW) in addition to an energy market (kWh) since, in their view, energy markets alone do not stimulate new investment. One supporter of the *Energiewende* noted that addressing market design is critical, and that if it is not addressed swiftly and comprehensively, the energy transition will fail.[89] The German utilities ESI interviewed largely agreed on the need for a new policy to enable changes in market design, but emphasized that these changes must allow the market to work and not be command-and-control oriented.

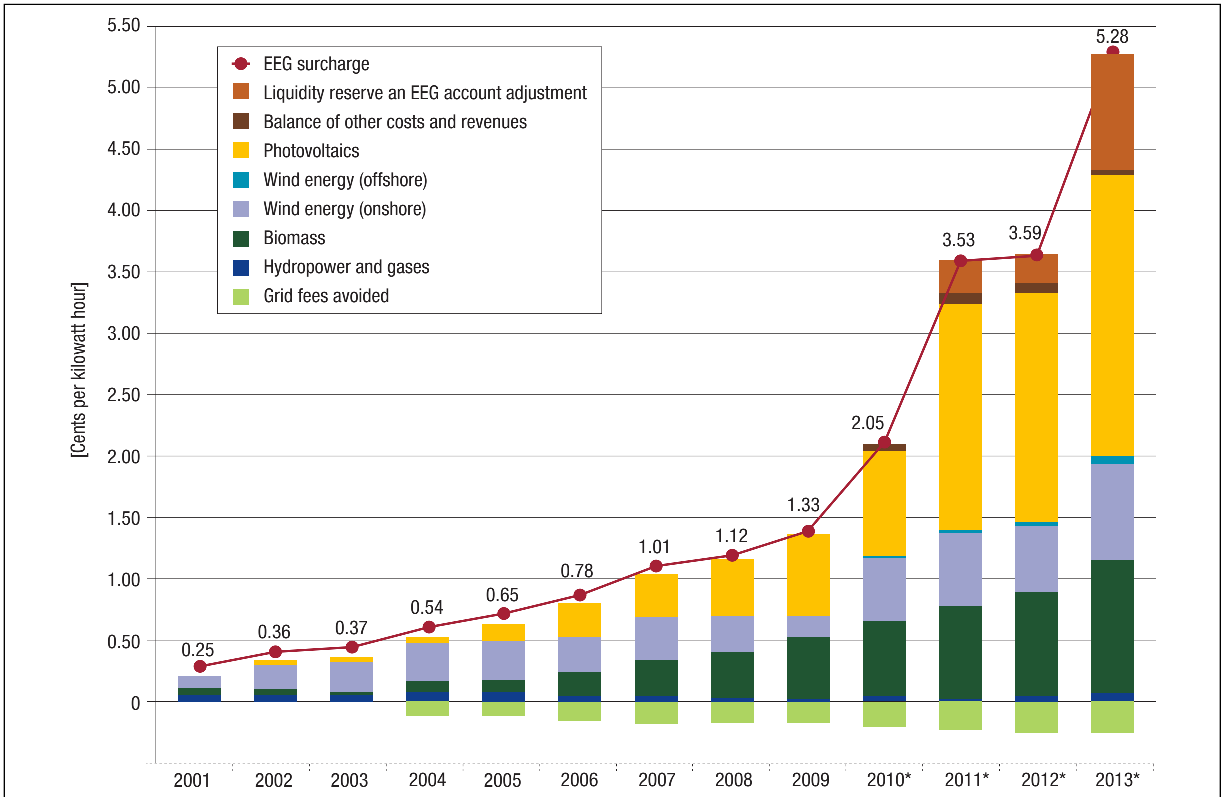
There are also concerns about the impact of rising costs on consumers. The EEG-Umlage—the feed-in-tariff surcharge passed on to households—has increased from €1.33 cents/kWh in 2009 to €5.28 cents/kWh in 2013 (see **Exhibit 4**). The average electricity price for a three person household has increased from €14 cents/kWh in 2000 to €29 cents/kWh in 2013,[90] giving Germany the second highest residential rates in the OECD (see **Exhibit 5**).

However, there are several factors to be considered in assessing the role of the EEG-Umlage and the role of the transition to renewables in the rising cost of electricity for households. First, there are other taxes and levies in the overall final cost per kWh of electricity not related to the EEG (see **Exhibit 6**). In 2013, the EEG surcharge accounted for 18 percent of the household energy price, although this share has doubled since 2010.[91] In addition, the rising cost of conventional fuels has contributed to the generation, transmission, and distribution component accounting for 45 percent of the total increase since 2000, while the EEG-Umlage accounted for 28 percent.[9]

Second, the rising costs of the EEG-Umlage for households have occurred in part owing to industry exemptions and the way in which the surcharge is calculated. As noted, the surcharge is the difference in the FIT paid to renewable generators and the wholesale price on the Leipzig exchange. A lower wholesale price means a higher EEG-Umlage is required to cover the costs of

[87] See *The Economist*, "How to lose half a trillion euros," October 2013.
[88] For example, see "12 Insights on Germany's Energiewende," Agora Energiewende, February 2013.
[89] Private comment.
[90] Data from Eurostat, accessed 2 May 2014, http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables.
[91] *Monitoring Report 2013*, Bundesnetzagentur, January 2014, 58.
[92] Michael Weber, Christian Hey, and Martin Faulstich, "Energiewende – A pricey challenge?" CESifo DICE Report, vol. 10, no. 3, 3 March 2012, pp. 16-23. Since 2000 the EEG-Umlage accounted for €3.39 cents/kWh of the total increase excluding VAT, while the generation, transmission and distribution component accounted for €5.43 cents/kWh of the total excluding VAT.

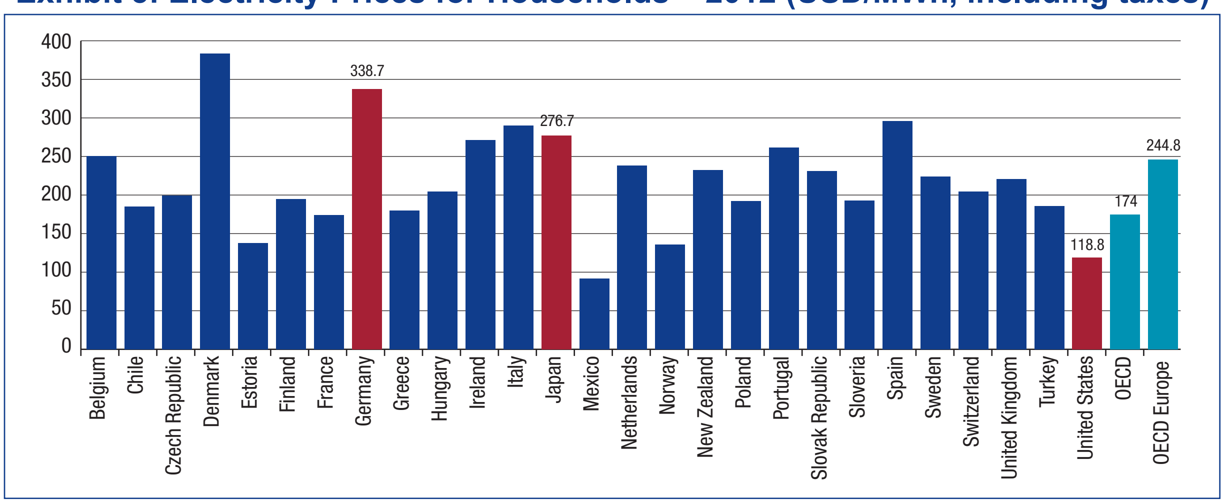
Exhibit 4: Development of EEG Surcharge and Components (2001 to 2013)



Sources: IfnE [7], BDEW [23]

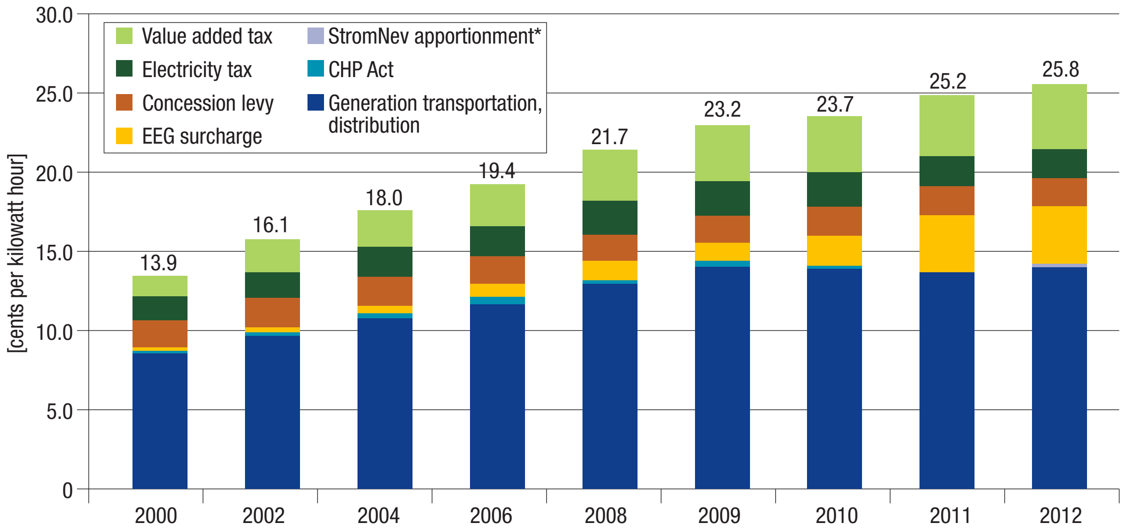
Source: *Renewable Energy Sources in Figures: National and International Development*, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), July 2013, 38. See document for BMU's citation of specific sources.

Exhibit 5: Electricity Prices for Households – 2012 (USD/MWh, including taxes)



Source: "Energy Prices and Taxes," OECD, http://www.oecd-ilibrary.org/sites/9789264185715-en/02/02/index.html?contentType=&itemId=/content/chapter/9789264185715-19-en&containerItemId=/content/book/9789264185715-en&accessItemIds=/content/book/9789264185715-en&mimeType=text/html.

Exhibit 6: Cost Components for One kWh of Electricity for Household Consumers in Germany



Sources: 1fnE [7], BDEW [23]
* Discrepancies due to rounding
All electricity consumers are charged the Strom/NEV apportionment on the basis of section 19 of the Electricity Network Charges Ordinance (Strom NEV). Since January 2012 it has funded the exemption of energy-intensive companies from grid-fees.

Source: *Renewable Energy Sources in Figures*: *National and International Development,* Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Federal Republic of Germany, July 2013, 39. See document for BMU's citation of specific sources.

renewable deployment. That higher surcharge is largely passed on to residential consumers since the law provides exemptions from the surcharge for certain large industrial consumers with high energy costs and businesses facing international competition (more on this in the following section).

Finally, while the cost per kWh has gone up for household consumers, the cost of electricity as a percentage of total household expenditures has remained relatively constant at around 2 percent.[93]

ECONOMY AND INDUSTRIAL COMPETITIVENESS

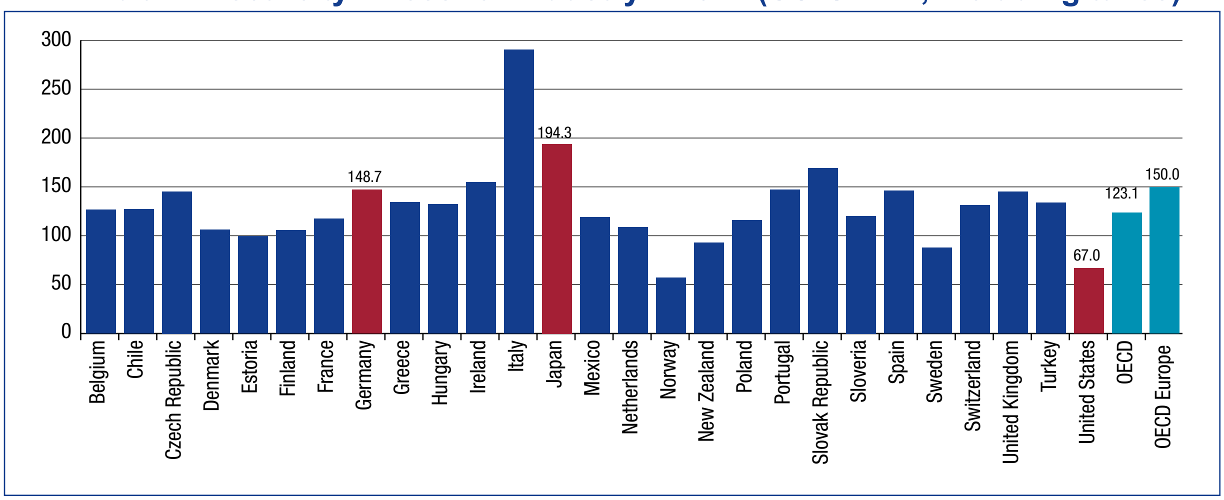
In addition to the impact on the electricity market, utilities, and households, concerns have also been raised over the broader implications of the *Energiewende* on the economy and industrial competitiveness. As shown in **Exhibit 2**, annual costs of the EEG have reached €20 billion. As the EEG-Umlage increased sharply since 2010 and as German elections approached in September 2013, there were increasing calls to rein in the costs. The German Minister for Energy and the Environment warned against a possible "dramatic de-industrialization" and the "need to control the expansion of renewable energy…and reduce costs so that it remains affordable."[94] In February 2014, the Commission for Research and Innovation, established by Parliament, issued a report declaring that the EEG should be discontinued since it was not an effective instrument for climate protection or technology innovation.[95]

[93] BMWi and BMU, *First Monitoring Report 'Energy of the future' – Summary*, Federal Republic of Germany, December 2012, 8.
[94] Melissa Eddy, "Germany official sounds a warning," *New York Times*, 21 January 2014.
[95] Madeline Chambers, "Germany must scrap its green energy law, say experts," *Reuters*, 26 February 2014.

Specifically, utility industry representatives and other critics of the energy transition caution that rising costs will drive industry to relocate to countries with lower energy costs (see **Exhibit 7**). For example, BASF, a major German chemical company, has invested in facilities in the U.S. and the group representing European steel manufacturers has specifically cited lower gas and electricity prices in the U.S. as placing European firms at a competitive "disadvantage."[96] In a recent report, IHS CERA claimed that the growing difference between Germany's industrial electricity price and a benchmark price of its key trading partners resulted in net export losses of €52 billion in 2008-2013.[97]

Nevertheless, industry is benefiting from lower wholesale prices: One estimate indicates that the "merit order effect" reduces wholesale prices by €0.89 per kWh, or around €5 billion annually, and this offsets some of the cost impact of the EEG surcharge.[98] Moreover, there is increasing evidence that wholesale energy prices are providing a competitive advantage for German industry. The organization representing large energy consuming industries in France announced that the competitiveness of its member companies is threatened in part owing to German industry paying 35 percent less for electricity in the coming year.[99] Bloomberg also projects that electricity in the U.K. will be 85 percent more expensive than in Germany in 2015.[100] Moreover, exemptions from the EEG-Umlage also are benefitting industry: companies receiving the exemption consume 18 percent of all electricity but pay only 0.3 percent of the surcharge, resulting in rising costs being borne by a limited number of households.[101] More and more companies have demanded the exemptions, rising from 53 in 2004 to over 2,000 in 2013, with exemptions totaling €5.1 billion per year.[102]

Exhibit 7: Electricity Prices for Industry – 2012 (USD/MWh, including taxes)



Source: "Energy Prices and Taxes," OECD, http://www.oecd-ilibrary.org/sites/9789264185715-en/02/02/index.html?contentType=&itemId=/content/chapter/9789264185715-19-en&containerItemId=/content/book/9789264185715-en&accessItemIds=/content/book/9789264185715-en&mimeType=text/html.

[96] Michael Birnbaum, "European industry flocks to U.S. to take advantage of cheaper gas," *Washington Post*, 1 April 2013.

[97] "A More Competitive Energiewende: Securing Germany's Global Competitiveness in a New Energy World - Executive Summary," IHS, vol. 1, March 2014, http://www.vci.de/Downloads/Media-Weitere-Downloads/2014-03-IHS-Report-A-More-Competitive-Energiewende-English.pdf.

[98] See BMU, Renewable Energy Sources in Figures, July 2013, 41.

[99] Tara Patel, "France's industrial giants call for price cap on nuclear," *Bloomberg*, 17 March 2104.

[100] Rachel Morison, "U.K. power price to double German on wind, solar: energy markets," *Bloomberg*, 14 June 2013.

[101] Weber et al., "Energiewende-A Pricey Challenge?"

[102] "Tilting at windmills: Germany's Energiewende bodes ill for the country's European leadership," *The Economist*, 15 June 2013, http://www.economist.com/news/special-report/21579149-germanys-energiewende-bodes-ill-countrys-european-leadership-tilting-windmills.

Japan

Electricity Market and Consumers

The nuclear shutdown and rising fossil fuel costs are threatening the financial health of utilities in Japan. The nine Japanese utilities with nuclear assets lost a total of ¥2.4 trillion in 2011-2012, and cumulative losses for those utilities were ¥171 billion in the second quarter of 2013 alone.[103]

In addition, compared to the period before the Fukushima accident, electricity prices have increased 28 percent for a typical household, reaching ¥8,004/month (approximately $80/month).[104] Price increases were granted by the government for seven of the electric power companies on the assumption that their nuclear power plants would be restarted. However, if nuclear reactors are not restarted the government may need to raise electricity prices again. Opponents of restarting any nuclear power plants argue that the economic benefits of bringing nuclear plants back online pale in comparison to what would be the cleanup costs in the event of another nuclear accident. According to an official in METI, the total cost of cleanup and compensation to affected businesses and individuals in the wake of the Fukushima disaster has thus far amounted to $105 billion. Furthermore, Japanese power companies are currently spending an estimated $1 billion to meet new nuclear power plant safety standards.[105]

Economy and Industrial Competitiveness

Increasing dependence on fossil fuels also is having serious impacts on the broader economy. Japan's trade balance fell into deficit in 2011 for the first time in 31 years, growing to ¥4.4 trillion, and to ¥8.2 trillion in FY 2012.[106] In FY2013 the government estimates that Japan will have to pay ¥3.63 trillion more for fossil fuel imports compared to 2010.[107]

One criticism expressed in our discussions is that while the FIT in Japan is set to ensure profits for renewable energy companies, it does not account for the added load on the grid operated by regional utilities. Furthermore, the cost of the tariff puts large electricity-consuming industries at a disadvantage. In particular, this system affects large manufacturing industries that drive the Japanese export economy. In anticipation of such burdens, changing market conditions, and new technological improvements, the FIT program mandates an annual review of the purchase price as well as measures to reduce the surcharge for larger commercial electricity consumers.[108]

Representatives of the Japanese electric power industry expressed caution about the impacts of large scale, rapid renewable energy deployment. Some noted "hidden costs" citing that the lesson of Germany is that the variable nature of renewables and priority dispatch rules give renewables a skewed advantage to generate electricity, and adversely affect the efficiency and profitability of traditional sources of power. However, studies indicate that, while priority dispatch and other incentives can result in the merit order effect and the loss of market share for conventional generators, these impacts are mainly the result of the low short-run cost of renewable generation.[109]

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[103] Ben McLannahan, "Nuclear freeze chills Japan's cash-strapped utilities," *Financial Times*, 13 September 2013.
[104] Estimate provided by Japanese government official in private meeting, December 2013.
[105] Private meeting: Japanese government official, Howard Baker Forum, 3 March 2014.
[106] Japan Ministry of Finance, "Trade Statistics," Government of Japan, http://www.customs.go.jp/toukei/shinbun/trade-st_e/2013/201338ce.xml.
[107] Estimate provided by Japanese government official in private meeting, December 2013.
[108] Private meeting, ANRE-METI, 18 February 2014.
[109] "The power of transformation: Wind, sun, and the economics of flexible power systems," IEA, 2014, 29.

FOSSIL FUELS AND CO_2 EMISSIONS

There is mounting concern and some criticism that the shutdown of nuclear generating capacity in Germany and Japan is leading to growing use of fossil fuels, increasing CO_2 emissions, and creating complications for meeting longer-term climate policy goals. Indeed, both countries have seen increases in GHG emissions in the last two years. Although the specific circumstances and policy and market dynamics differ between these countries, the common challenge is that the removal of a significant source of carbon-free capacity—along with the rapid deployment of renewable energy—impacts both the electricity market and strategies to reduce GHG emissions.

Germany

From 2011 to 2013, the German government estimates that greenhouse gas emissions increased 2.4 percent, with CO_2 emissions rising by nearly 3 percent (see **Exhibit 8**). This increase has been driven in part by increased use of hard coal and lignite in the electricity sector. For example, lignite's use in electricity production has grown 9.4 percent in the period from 2010 to2012.[110] In 2012, 2.7 GW of lignite-fired capacity became operational and 8 GW of hard coal and lignite capacity is under construction.[111] While significant progress has been made in reducing GHG emissions since 1990 (by 24 percent), this recent trend calls into question the ability of Germany and the EU to meet their goals for 2020 and beyond. According to the vice president of the Federal Environment Agency, "It is worrisome that the trend towards coal-generated electricity became even more pronounced in 2013. If it continues, we can hardly expect to achieve the federal government's climate protection goal for 2020"[112] (see **Exhibit 9**).

Nevertheless, criticism that increased coal-fired electricity generation is a result of the policies of the *Energiewende* does not consider several unrelated market factors that have converged to reduce coal prices, especially in relation to gas. First, the boom in natural gas production in the United States has led to enhanced gas use (backing out coal) in power generation, spurring a rise in U.S. coal exports to Europe, which in turn results in abundant coal supply and depressed prices.

Second, the CO_2 emissions profile of Germany has changed several times since 2005, due largely to the EU's Emissions Trading System (ETS). After the ETS started in 2005, there was a rise in CO_2 emissions because of an oversupply of allowances (certificates or permits to emit). Emissions then declined in 2008-2009 after ETS's CO_2 prices increased and the global financial crisis occurred. However, since 2011 there has been an increase in CO_2 emissions owing to another oversupply of ETS allowances. Thus, the recent short-term rise in emissions is due in part to an oversupply of ETS allowances.

The EU has adopted recently a "backloading" policy, a short-term postponement of auctions designed to reduce the number of allowances in order to increase CO_2 prices, although it has not had a substantial impact on prices thus far. It is possible that sometime in 2018 to 2020 auctions could resume, placing some downward pressure on prices. However, there is skepticism of the ETS: the CO_2 price has not fostered investment in low emissions technology over the last 5-6 years,

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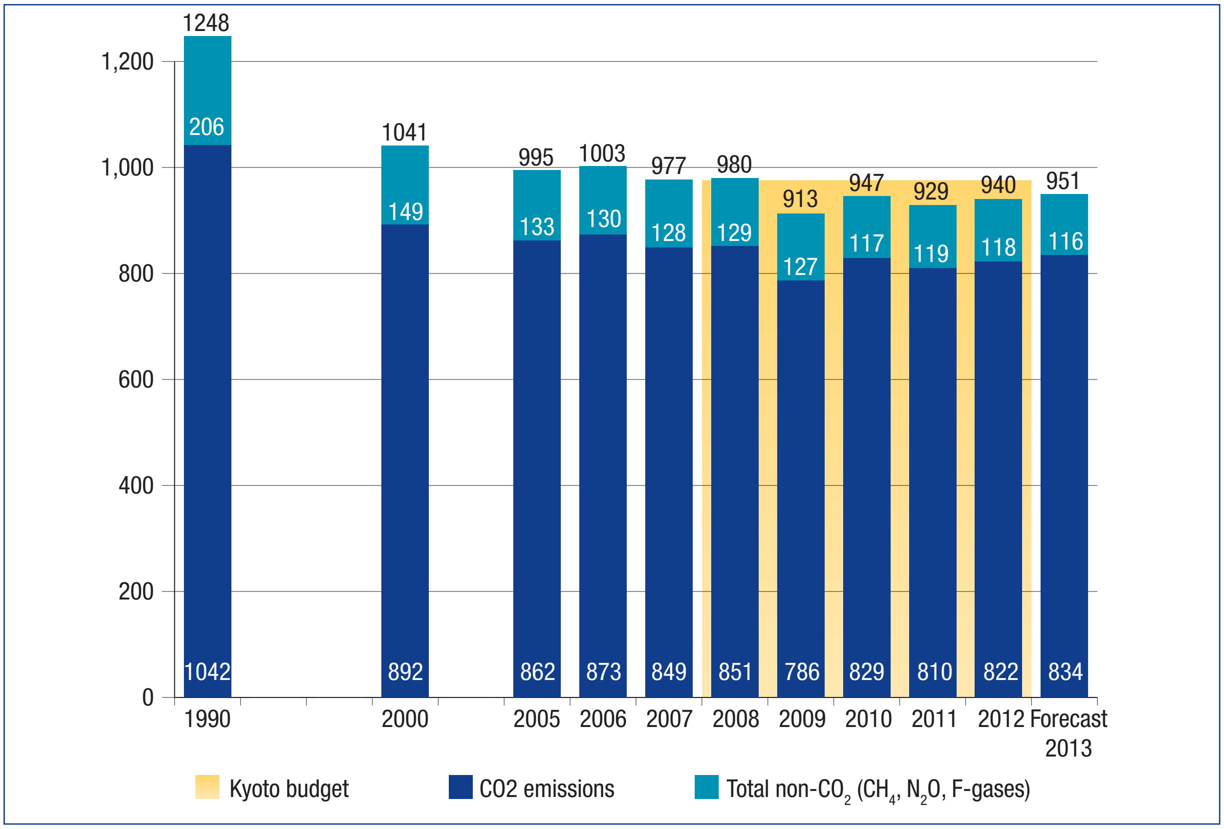
[110] "Evaluation Tables on the Energy Balance 1990 to 2012," Arbeitsgemeinschaft Energiebilanzen (AGEB), 31 July 2013, http://www.ag-energiebilanzen.de/EN/downloads/evaluation-tables-on-the-energy-balance-1990-to-2012/evaluation-tables-on-the-energy-balance-1990-to-2012.html. AGEB is a working group founded by energy related associations and research centers.

[111] "Outlook for new coal-fired power stations in Germany, the Netherlands, and Spain," Pöyry Management Consulting, April 2013, 13.

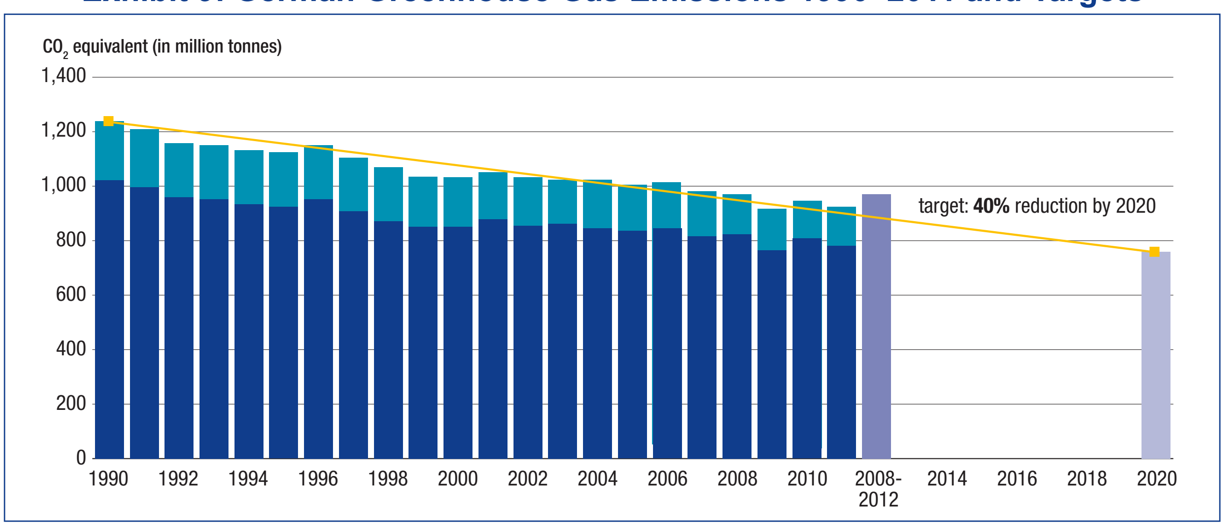
[112] "Greenhouse gas emissions rise again slightly in 2013, by 1.2 per cent," Federal Environment Agency, Federal Republic of Germany, 10 April 2013, http://www.umweltbundesamt.de/en/press/pressinformation/greenhouse-gas-emissions-rise-again-slightly-in

Exhibit 8: Greenhouse Gas Emissions in Germany, 1990 - Forecast 2013 (in Mt CO_2 equivalents)



Source: Federal Environment Agency, Federal Republic of Germany, data as of 25 February 2014.

Exhibit 9: German Greenhouse Gas Emissions 1990–2011 and Targets



Source: First Monitoring Report "Energy of the future"–Summary, Federal Ministry of Economics and Technology (BMWi) and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), December 2012, 7.

creating doubts that the EU carbon market will have any serious impact on renewables investment before the mid-2020s. As one German utility representative stated, "renewable energy policies have been more effective than climate change policies."

Third, the coal-fired capacity that has recently come online and is under construction was planned in the period from 2006 to 2008 under a very different investment climate.[113] This has changed, however, and as a result of low prices (from decreased demand and the merit-order effect of more renewable generation), environmental opposition, and technical problems, a significant amount of planned coal-fired capacity additions have been postponed (3.4 GW), or abandoned (22.1 GW) since 2007.[114] Thus, the recent trend of coal-fired additions is a result of investment decisions taken pre-Fukushima and going forward it is expected that market dynamics will undermine the economic rationale for building any other coal plants. In fact, one analysis suggests that total coal and lignite capacity—accounting for plants under construction and retirements—will decline from 48 GW currently to 40 GW in 2020 and 23 GW in 2030.[115]

The market forces described above are having an impact on natural gas.[116] In particular, low coal prices compared to levels in the 2007-2010 period have helped reduce average electricity prices prompting a switch from gas to coal.[117] With poor margins and with many gas-fired plants becoming back-up facilities, gas does not play a significant role in utility planning in Germany. For some, this situation represents not only the failure of the *Energiewende* but also a huge lost opportunity. In this view, current policy and market dynamics not only make gas uncompetitive relative to coal, but also do not take advantage of Germany's own shale gas resources or its role as the hub of the European gas market, and limit the opportunity for future imports of U.S. LNG.[118] Moreover, the recent crisis in Ukraine bolsters the argument that taking advantage of these additional natural gas sources is a way to reduce dependence on Russian imports, thus improving energy security.

Japan

The nuclear shutdown in Japan and the subsequent increase in fossil fuel use have led to a rise in CO_2 emissions. From FY2010 to FY2012, CO_2 emissions from the ten regional electric power companies increased 30 percent (by 112 million tonnes) to account for 40 percent of total energy-related CO_2 emissions (up from 33 percent in FY2010).[119]

As noted, this increase is driven by the rising use of imported fossil fuels to replace idled nuclear capacity. Japan is expected to continue expanding fossil fuel capacity: there are plans to begin operation of fourteen new gas and coal power plants by the end of 2014, in large part to reduce Japan's

[113] This involved a proposed favorable emissions allowance scheme, high projected demand, and high dark spreads. See Pöyry Management Consulting, "Outlook for new coal-fired power stations in Germany," 14.
[114] Ibid., 16.
[115] Ibid., 17.
[116] Another factor is that most long-term gas contracts in Europe had traditionally been indexed to oil prices. However, since late 2008, early 2009, many existing contracts as well as new contracts have de-linked oil and gas, and more and more gas is traded on spot markets.
[117] See "The German Energiewende and its Climate Paradox," Agora Energiewende, April 2014.
[118] One German utility official cautioned that U.S. LNG exports to Europe will not occur before 2020, especially since the U.S. will get a better price selling to Asia. Indeed, U.S. LNG contracts to date also have been signed with customers in England, Spain, and Italy. Moreover, "politically it may be difficult to tell the coal interests in Germany that U.S. LNG is good for European energy security" (German utility official, private interview).
[119] Figures provided by Japanese government.

use of oil in power generation.[120] These new plants represent a $7 billion investment and a 6.4 percent increase in fossil fuel generation capacity. Moreover, in early 2013 the government relaxed environmental rules on building new coal-fired power plants.[121]

The increased use of fossil fuel generation led Japan to reduce its emissions targets in November 2013 from the previous target of 6 percent below 1990 levels to a new target of 3 percent higher than 1990 emissions.[122]

To address rising CO_2 emissions and to support supply diversity and competitiveness, the government is promoting imports of LNG from a variety of sources. For example, the government is encouraging Japanese companies to participate in upstream LNG development projects in Russia, Canada, Mozambique, Australia, and the United States. Japan is especially keen on securing U.S. LNG imports after 2017, and the government views the price arbitrage between the U.S. and Asian markets as a key driver for this opportunity. After accounting for liquefaction costs ($3-4/mmbtu) and transport ($3/mmbtu), the delivered U.S. price of gas to the Asian market would be about $6-7/mmbtu above Henry Hub (the benchmark price for natural gas in the U.S.), still lower than Japan's LNG import prices. However, Asian LNG prices have recently declined to three-year lows of $11/mmbtu suggesting that by the time the U.S. gets ready to export the market may not be as attractive.[123]

In addition, for Japan to get large volumes of U.S. LNG exports, there are major potential market developments and uncertainties that it must consider. First, competing supplies could come into the market from a variety of sources, depressing prices and making it less attractive to invest in developing high cost LNG projects. These sources include Central Asia, Mozambique, Papua New Guinea, and Australia. Second, in the face of growing competition, Russia may abandon its oil indexation approach to gas contracts, bringing cheaper gas to global markets. Japanese gas companies also are studying the cost of pipeline gas from Sakhalin to Japan. The preliminary conclusion is that this could not only be more competitive than LNG from Vladivostok, but also could compete with U.S. LNG. There are expectations that Japan will discuss this issue with Russian partners as part of an overall effort to enhance the stability of natural gas supply, although economic sanctions on Russia in the wake of events in Ukraine seriously undermine this approach.

Another important factor is the likelihood of coal remaining competitive in the Asian market, especially in the absence of a global climate agreement. There are a number of world-class projects planned or under construction in various countries (Mongolia, Mozambique, Indonesia, and Kazakhstan). Coal's competitiveness is also supported by a recent Asian Development Bank report that estimates that by 2035 coal will be the primary fuel in global trade.[124]

Thus, Japan is placing an emphasis on portfolio management in LNG, but there are many factors and dynamics potentially having an impact on the future world gas market.

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[120] Osamu Tsukimori and Rebekah Kebede, "Japan on gas, coal power building spree to fill nuclear void," *Reuters*, 15 October 2013, http://www.reuters.com/article/2013/10/16/us-japan-power-outlook-idUSBRE99F02A20131016.

[121] Mari Iwata, "Japan's Answer to Fukushima: Coal Power," *Wall Street Journal*, 27 March 2014, http://online.wsj.com/news/articles/SB10001424052702304688104579464942892719528.

[122] Hiroko Tabuchi and David Jolly, "Japan Backs Off From Emissions Targets, Citing Fukushima Disaster," *New York Times*, 15 November 2013, http://www.nytimes.com/2013/11/16/world/asia/japan-shelves-plan-to-slash-emissions-citing-fukushima.html?_r=0.

[123] Eric Yep, "Asian LNG prices at three year lows," *Wall Street Journal*, 9 July 9 2014.

[124] "Energy Outlook for Asia and the Pacific (2013)," Asian Development Bank, October 2013, http://www.adb.org/publications/energy-outlook-asia-and-pacific-2013.

4. Unique Themes

In addition to the common themes described in the previous chapter, there are significant differences between the two countries which we have discussed throughout this brief. For example, Japan's reliance on energy imports in the electricity sector is far greater than Germany's, and there is currently much more debate and uncertainty in Japan over setting objectives and implementing overall energy policy. Moreover, limited interconnections among the utilities' service territories (owing to an electricity system based on two frequencies), absence of interconnections with neighboring countries' markets, and geographic constraints (limited suitable land area) all make a transition to higher levels of variable renewable energy very challenging in Japan.

In this section, we focus on two additional factors having an impact on large-scale deployment of renewable energy: the German energy transition's linkage with neighboring countries and the EU region, and the Japanese government's plan to restructure the electricity sector.

REGIONAL ISSUES IN GERMANY

One challenge unique to Germany, relative to Japan, is that of coordination with neighboring systems and integration with the broader European electricity market. This issue has been highlighted by excess variable renewable electricity generation in Germany causing problems with neighboring networks. Specifically, because of a lack of transmission capacity to bring large amounts of wind-powered electricity from northern Germany to demand centers in the south, power has flowed to Poland and the Czech Republic. These "loop flows" have caused transmission constraints and impacted the economics of those neighboring domestic markets.[125]

As a result, the German transmission companies have increased their coordination with neighboring utilities especially in the planning and deployment of phase shifters to steer the load flows to the German system in order to relieve the Polish and Czech grids. An agreement has been finalized working out cost sharing and operational responsibilities. The TSOs also have initiated agreements with neighbors for redispatching and auctioning (trading) power with costs included in German network tariffs.

The issue of loop flows has raised the broader challenge of coordinating the *Energiewende* with EU policy. In Germany, experts from industry and government alike largely agree that the German energy transition from the outset needed to

[125] IEA, "Germany 2013 Review," 140-141.

be better coordinated with the EU's stated objective of creating a single internal electricity market. One respected group states that with regard to the *Energiewende* and the EU "thus far the two have not been considered in tandem. There is almost no sound analysis of the way the two interact."[126]

The EU's overall objective is to achieve a regional internal electricity market in order to realize the benefits of interconnected systems and to improve the capacity to better balance supply and demand while ensuring security of supply. Thus, EU policy promotes harmonization of rules and regulations, pricing, and other market design components.[127] This approach is viewed as critical to facilitate the EU's renewable energy targets, since interconnected markets and larger balancing areas provide greater flexibility in integrating variable generation sources.

The experience of Germany illustrates the benefits and challenges of this approach. The internal electricity market has allowed excess German wind power in the north to flow to its neighbors—albeit with repercussions on those countries—and permitted imports of needed electricity when nuclear plants were taken off-line in the immediate aftermath of Fukushima.[128] Nevertheless, as Germany (and other European countries) increase the share of renewable energy in their electricity portfolios there will be greater urgency to strengthen and expand regional transmission infrastructure and supporting cross border policy mechanisms.

There has been some recent notable progress in achieving these goals. For example, the European Commission has called for member states to target the interconnection of 15 percent of installed generation capacity by 2030 (up from the current target of 10 percent).[129] The EU is also supporting a pilot project to promote market coupling among 14 member states in northern Western Europe.[130] In Germany, the TSOs have increased their cooperation with neighboring network operators and are working with the European Network of Transmission System Operators for Electricity (ENTSO-E) on EU grid issues.[131]

In general, however, policy in support of renewable energy at the domestic and EU levels and the rate of renewable energy penetration throughout the region are outstripping efforts to create an interconnected internal electricity market. Specifically, the *Energiewende* increases the pressure on Europe's electricity networks, making imperative the inclusion of neighboring countries in the planning of Germany's energy system.[132]

The challenge of planning and coordinating Germanys' energy transition with broader EU policy is illustrated in the debate over capacity markets. As noted, the merit order effect is reducing the competitiveness of conventional fuels, raising concerns over security of supply.[133] This dynamic is playing out in several European countries in addition to Germany, prompting serious consideration of using capacity markets to enhance

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[126] See "European Energy Cooperation: What is Europe's importance for the *Energiewende*?" Agora Energiewende website at http://www.agora-energiewende.org/topics/european-energy-cooperation/what-is-europes-importance-for-the-energiewende/.

[127] Ibid.

[128] Thomas Sattich, "Germany's Energy Transition and the European Electricity Market: Mutually Beneficial?" *Journal of Energy and Power Engineering*, no. 8, 2014, 270.

[129] "Energy security: Commission puts forward comprehensive strategy to strengthen security of supply," Press release, European Commission, Brussels, 28 May 2014.

[130] "Progress towards the Internal Energy Market 2014: Pilot project for EU wide electricity trade starts today," Press release, European Commission, Brussels, 4 February 2014.

[131] For example, ENTSO-E has initiated the development of an indicative 10-year plan.

[132] Sattich, "Germany's Energy Transition," 271.

[133] Increasing penetration of renewables is one factor in the declining competitiveness of some conventional fuels. As noted elsewhere in this brief, declining electricity demand, the status of the ETS, and inter-play of competing fuel prices—influenced by global market trends—also have an impact.

domestic supply diversity by providing an additional revenue source (capacity) for conventional generators in addition to selling kWh (energy). The problem, however, is that establishing a capacity market as a domestic policy instrument is at odds with the EU direction of harmonizing markets and using interconnections as the "preferred approach to enhancing security of supply."[134]

ELECTRICITY SECTOR RESTRUCTURING IN JAPAN

METI's plans to increase renewable energy in the electricity portfolio rely upon three key factors: stable operation of the FIT program, improving the distribution network, and sector reform centering on unbundling and deregulating the electric power sector. Electricity sector reform is arguably the most complex policy issue confronting Japan. Combined with the inherent challenges of integrating renewables on a large scale, the prospect of completely reforming the electricity system exacerbates uncertainty, deterring necessary investment and complicating future planning.

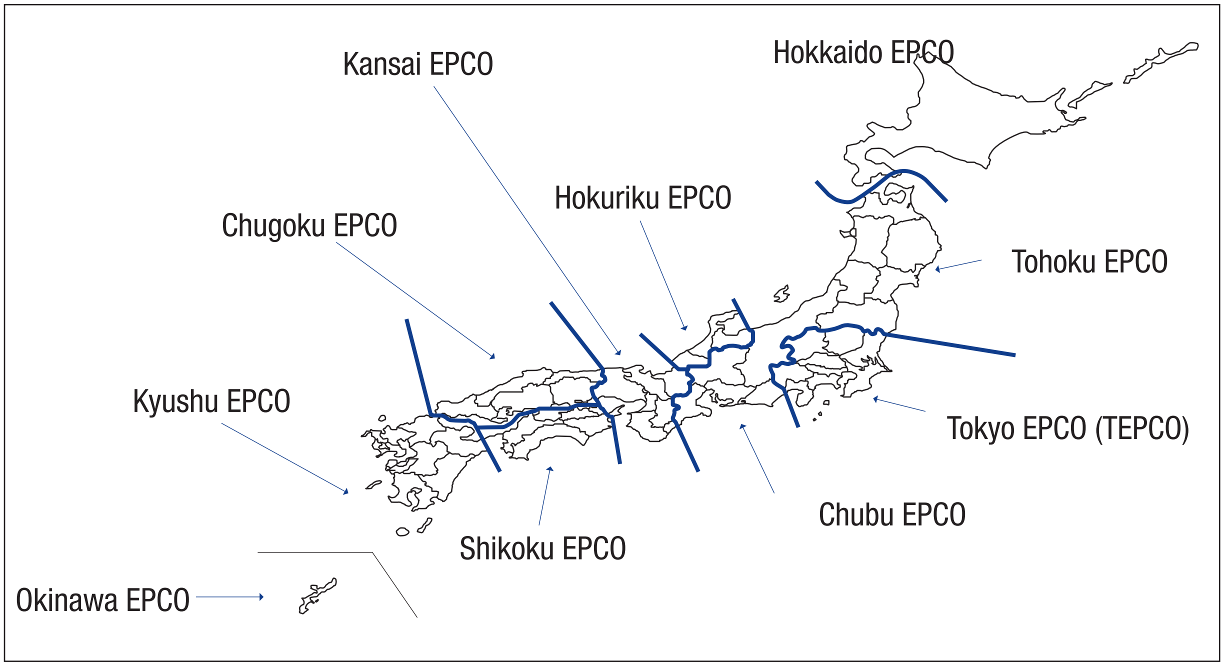
While Germany and many parts of the U.S. have gone through market liberalization, including unbundling, the Japanese electricity system remains dominated by 10 vertically-integrated regional electric power companies that own approximately three-quarters of generation capacity and operate transmission and distribution networks supplying 88 percent of the country's electricity consumption (see **Exhibit 10**).[135]

However, in 1995 METI began to open the electricity market to competition by allowing independent power producers. In 2000, a new policy introduced partial retail competition and the separation of transmission accounting and distribution services from power generation services. Additional reforms expanded retail competition and established a wholesale power exchange market in 2005. With the implementation of these reforms Japan's electricity market gradually has become what the government calls "partially liberalized." While these policy changes have begun to encourage competition, the regional monopoly utilities continue to dominate wholesale and retail markets.[136] Regulatory and structural hurdles provide disincentives for new market entrants limiting competition.

The 2011 Fukushima disaster pushed the government to propose more extensive reforms. The accident shed light on the weaknesses of the current regional monopoly structure: excessive price controls, a lack of competition, limitations of the industry structure to handle changes in the energy mix (i.e. scaling up renewables), and the inability of major utilities to share electricity between regions.[137] The latter factor proved especially important. The country is divided into 50 Hz and 60 Hz regions and this constrained Tokyo Electric Power Company (TEPCO) in drawing electricity from western Japan, which uses 60 Hz frequencies, when its nuclear power production was halted. The limited capacity to transfer power across systems with different frequencies proved to be grossly inadequate, resulting in widespread blackouts following the disaster. Total potential capacity for power exchange by TEPCO is only 3.4 GW, constituting barely 6.3 percent of peak

[134] "EU Energy Policy and National Interests Conflict at the Expense of European Unregulated Utilities Credit Quality," Moody's Investors Service, 1 July 2014, 6.
[135] R.S. Jones and M. Kim, "Restructuring the Electricity Sector and Promoting Green Growth in Japan," *OECD Economics Department Working Papers*, OECD Publishing, no. 1069, 5-6.
[136] Jones and Kim, "Restructuring the Electricity Sector," 14-15.
[137] Electricity Market Reform Office Agency for Natural Resources and Energy (ANRE), "Electricity Market Reform in Japan," METI, Government of Japan, November 2013, http://www.meti.go.jp/english/policy/energy_environment/electricity_system_reform/pdf/201311EMR_in_Japan.pdf.

Exhibit 10: Japan's Major Electric Power Companies



Source: METI, November 2013.

demand, while harmonizing frequencies across the country will cost ¥10 trillion ($98 billion).[138]

To address these institutional weaknesses, Prime Minister Abe in early 2013 submitted a reform package called *The Policy on Electricity System Reform*. The Policy was approved by the Cabinet on April 2, 2013 and has three broad objectives:[139]

- Securing a stable supply of electricity
- Keeping electricity rates as low as possible
- Expanding choices for consumers and business opportunities

There will be three main stages in the deregulation process:

- By 2015: Establishment of Cross-regional Coordination of Transmission Operators (OCCTO)
- By 2016: Full retail competition (expand to residential sector)
- By 2018-2020: Unbundling transmission and distribution from the general electric companies

The main function of the OCCTO will be to coordinate and balance supply and demand by aggregating and analyzing grid data from the electric power companies. It will also reinforce and manage cross-regional frequency adjustments and power transfers, improving the existing interconnection deficiencies. In the second step, around 2016, expanded retail competition will be

[138] Jones and Kim, "Restructuring the Electricity Sector," 12.
[139] "Electricity System Reform," METI, Government of Japan, http://www.meti.go.jp/english/policy/energy_environment/electricity_system_reform/index.html.

combined with regulated tariffs imposed on the 10 major utility companies. This step will free-up a ¥7.5 trillion market covering 77 million households for competition.[140] This market is expected to attract new businesses, including distributed generation and energy management companies, as well as new retailers offering packages ranging from gas plus electricity to peak-shift options. Finally, unbundling transmission and distribution services from the generation companies in the third step will entail forming independent transmission operators (ITOs) to manage the transmission networks in each region. The tariffs imposed on the utilities in the second step will be removed around this time.

The government plans to submit legislation in 2014 to mandate the second step and to submit a bill for the third step in 2015. This tentative schedule is subject to review if there is a threat to electricity supply stability or other concerns arise. The details of the reform package, specifically the provisions under which generation, retail, and transmission operations of utilities can be unbundled, are still up for debate. TEPCO has commenced reforming itself, separating its production, distribution and retail operations this year.

The government stresses that the main reform objectives are to overcome the challenges related to power exchanges across regions, which were made visibly apparent by the earthquake and the shutdown of nuclear power generation, and to introduce competition. There is also an expectation that, assuming some nuclear capacity comes back on line—and excluding fuel costs, surcharges, and taxes—prices should come down or remain flat as a result of market liberalization incentivizing players to innovate new ways to lower prices.

There are several areas of concern regarding the electricity system reform proposal in Japan. The first is the challenge of balancing the grid while integrating renewable energy, such as bringing large wind resources on the northern island of Hokkaido to mainland Honshu. The timeline for reform also raises questions. Considering it has taken decades for other countries (e.g., the U.S.) to deregulate their markets, Japan's plan to reform its system in the next four to six years may be too ambitious. One recognized expert recommends that Japan tackle establishing full retail competition last, prioritizing plans to establish a functioning wholesale market and expand, finance, and oversee transmission of a newly deregulated national grid.[141] The government argues that the reform is organized in a step-by-step program to allow for adjustments, and that with unbundling taking place in 2020, there will be a basic platform from which changes in the market can occur over five to 10 years, effectively lengthening the process.

[140] Aaron Sheldrick and James Topham, "Japan to open residential power market to competition", *Reuters*, 11 July 2014, http://www.reuters.com/article/2014/06/11/japan-power-regulations-idUSL4N0OS16F20140611.

[141] See comments of William Hogan at Brookings event on "Restructuring the Electricity Sector in Japan," Brookings Institution, Washington D.C., March 2014, http://www.brookings.edu/events/2014/03/13-restructure-electricity-sector-japan.

5. Lessons from Japan and Germany

Our research has revealed findings and lessons that are relevant for governments as they examine the most viable approaches for transforming their electricity portfolios. In this chapter, we describe these lessons with a particular focus on factors to be considered in deploying a high share of renewable energy into the mix.

ESI's discussions with stakeholders in Germany and Japan revealed several critical policy, market design, regulatory, technical, and infrastructure-related issues that need to be addressed early and in a cohesive, ongoing manner in order to integrate high levels of renewable capacity. Both the German and Japanese experiences illustrate just how challenging these issues are, but Germany also demonstrates that they can be addressed in a manner allowing renewable energy to play a much larger role in the electricity portfolio of the future.

Our findings and lessons are:

- Countries must set objectives and develop consistent, durable, and clear national policies to manage the complexity of large-scale renewable energy integration.
- A high level of renewable penetration presents unique challenges, but is manageable through a coordinated system-wide approach.
- Cost and wealth distribution impacts must be managed.
- Solutions must be tailored to local conditions and include monitoring and course correction mechanisms.
- Addressing transmission and grid challenges is critical.
- Renewables, especially distributed generation, are forcing changes in utility business models.
- Markets and industry structure matter.

COUNTRIES MUST SET OBJECTIVES AND DEVELOP CONSISTENT, DURABLE, AND CLEAR NATIONAL POLICIES TO MANAGE THE COMPLEXITY OF LARGE-SCALE RENEWABLE INTEGRATION

Increasing the share of renewable energy in the electricity portfolio and carrying out a major transformation of the power sector has real and dramatic implications, including cost and wealth distribution impacts. This makes a clear and coordinated program imperative, starting with setting overall objectives and then developing commensurate policies to achieve them. This level of policy clarity provides a predictable and stable business environment for utilities and other stakeholders in the electricity industry to plan and invest. Germany has been successful in setting objectives and implementing a supportive and stable policy framework, while Japan has struggled since Fukushima to make progress in redefining its overall energy policy owing to ongoing vacillation on the role of nuclear power in the nation's energy future.

In Germany, there is a consensus across society and among political parties on prioritizing environmental protection, and in particular, acceptance of the science of climate change and the need to reduce greenhouse gas emissions. There is also widespread support for moving away from nuclear power largely on environmental and safety grounds. However, renewable energy as a cornerstone of the *Energiewende* has been promoted as a way not only to meet environmental goals, but also to meet important energy security and economic objectives. Renewable policy is closely linked with industrial policy, adding a business case for asking German consumers to pay more for electricity: Germany's market share in the global renewable industry is much greater than its domestic demand for renewable electricity. From this perspective, the *Energiewende* helps Germany maintain and augment its value-added contribution in the global renewable energy supply chain. Renewable energy deployment also is viewed as a way to decrease reliance on imported fossil fuels, reducing vulnerability to volatile world prices for gas and coal.

This agreement on the overriding objectives of energy policy forms the foundational backing for the *Energiewende*, especially the move toward renewable energy. German policymakers see the energy transition as a worthwhile experiment in the global effort to address climate change, and accept that this will come at a high cost. As one architect of the EEG noted: "With the Renewable Energy Act that we created in 2000, we financed a learning curve that was expensive. But the good news is that we have learned in only 13 years to produce electricity with wind power and solar facilities at the same price as if we were to build new coal or gas power stations."[142] German consumers have been largely comfortable with this experimentation and have been willing to pay for a learning curve to support their convictions about climate change and renewables. The EEG has remained in place even as costs have risen, and successive governments across the political spectrum have continued to support the policy framework.

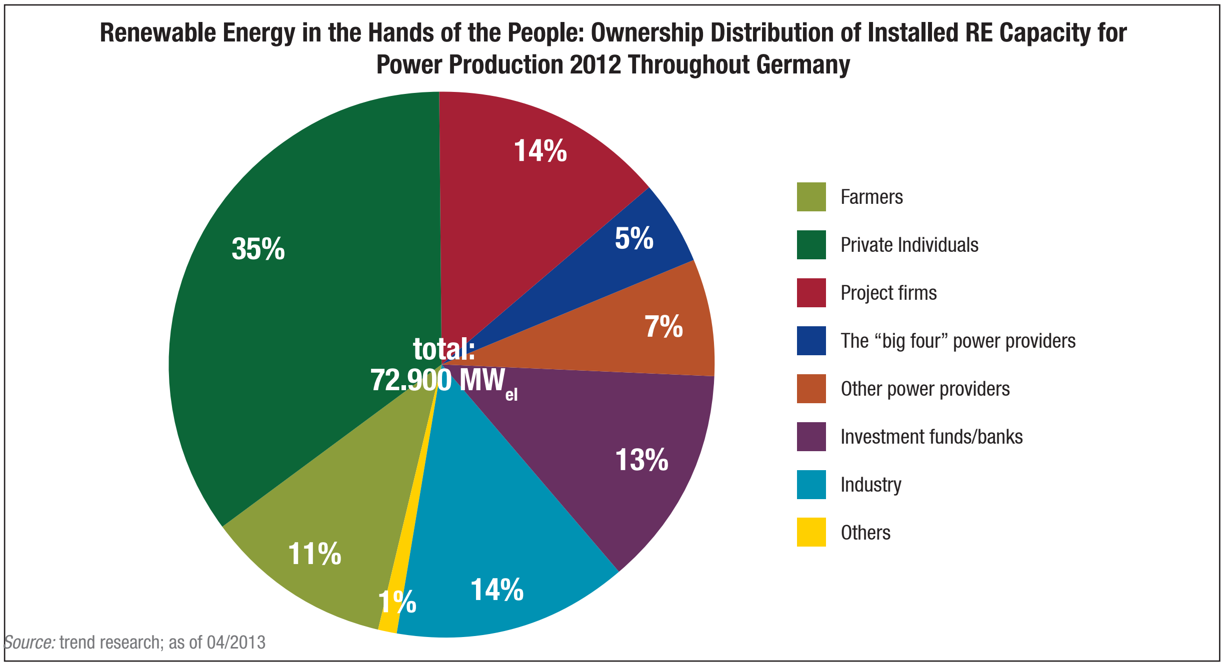
The German FIT has played a key role in this policy consensus and support for renewable energy. The guaranteed, long-term revenue stream for renewable generation under the FIT provides a stable and profitable framework for renewable technologies, creating investors and spurring continued political buy-in. Indeed, households, farmers, and other small enterprises comprise the majority of the owners of renewable energy in Germany (see **Exhibit 11**). The policy has generated a vocal and widespread "renewable constituency."

While recent dramatic cost increases for households and concerns over the *Energiewende's* impact on the electricity market as well as broader economic competitiveness are raising concerns—there was significant debate over energy policy during the recent German elections—there is no widespread call for shifting the overall objective of energy-climate policy. Even those critical of the *Energiewende* do not seek to overhaul the long-term goals of the energy transition. Rather, there is debate over how best to achieve them.

In Japan, with its limited natural resource base, the government has long focused on the security component of energy policy, and has successfully linked that objective with reducing dependence on imports, mitigating the potential for supply

[142] Melissa Eddy, "German energy push runs into problems," *New York Times*, 19 March 2014.

Exhibit 11: Breakdown of Renewable Energy Ownership in Germany



Source: Renewable Energies Agency, http://www.unendlich-viel-energie.de/english (used with permission).

disruptions and avoiding the high costs and price volatility of fossil fuel imports. The shutdown of nuclear capacity has accelerated a policy effort to deploy more renewable energy (promoted mainly through a feed-in-tariff), as well as the implementation of energy conservation programs. Renewable energy not only provides environmental benefits, but also contributes to the diversification of the electricity generation fuel mix, strengthening energy security and the economy by limiting imports of expensive fossil fuels.

While Fukushima has certainly cast greater doubt on nuclear power, rising energy costs and increasing dependence on the Middle East as a supplier of energy in the aftermath of the nuclear shutdown have caused policymakers to focus on rebuilding the consensus on security objectives, specifically underscoring the importance of re-starting some nuclear reactors as part of that effort.

Nevertheless, energy policy has been largely in flux since the Fukushima accident with the government continuing to fine-tune the specifics of a new approach. Indeed, there is continued heated debate regarding the role of nuclear energy and the suitability and cost of large-scale deployment of renewable energy. In particular, ongoing concerns and protests concerning the safety of nuclear power plants threaten to undermine the energy security rationale for nuclear energy, while the business community and electric utilities forcefully argue that dramatically reducing or eliminating nuclear energy from the electricity mix harms the economy and disproportionately damages their interests. These contending viewpoints have created a dynamic that complicates the government's consensus building in the development of energy policy, highlighting the importance of a coordinated and centralized approach to transformation of the electricity system.

In terms of specific policy mechanisms, the cornerstone of any approach is to promote stable investment conditions that greatly reduce or eliminate market price risk for renewable energy projects. One of the principal similarities between Germany and Japan is the use of the FIT. Policy-makers in both countries consider this policy tool to be superior to quotas or short-term financial incentives, and the most effective mechanism in providing a guaranteed long-term, revenue stream, stimulating more widespread deployment and bringing costs down. While the costs of some renewable technologies remain high compared to conventional fuels, it is well documented that renewable energy costs are declining globally and some technologies, in particular wind and solar, are becoming competitive with conventional fuels even without subsidies and direct policy support. For example, Citi Research indicates that the levelized cost of electricity for residential solar PV has fallen below average residential electricity prices in Spain, Germany, Portugal, Australia, and the Southwest U.S., and by 2020 it expects total system costs globally to decline 42 to 53 percent for residential installations and 47 to 63 percent for utility scale solar projects.[143]

A HIGH LEVEL OF RENEWABLE PENETRATION PRESENTS UNIQUE CHALLENGES, BUT IS MANAGEABLE THROUGH A COORDINATED, SYSTEM-WIDE APPROACH

High levels of renewable energy in the electricity mix are possible, presenting less of a challenge for technical integration than for existing business models and market design (see below). Moreover, cost-effective solutions exist to address technical as well as market design and regulatory challenges. Numerous recent studies have concluded that "proven technologies and practices can dramatically reduce the cost of operating high penetration variable renewable energy," including at penetration levels above 50 percent, without negative impacts on reliability[144] (see also **Box 3**). A recent analysis from the International Energy Agency stated that system integration of renewables is not a "significant challenge" at penetration levels of up to 10 percent of total generation, although "minimizing total system costs at high shares… requires a strategic approach to adapting and transforming the energy system as a whole."[145] What is needed is to think about power system design differently—from a focus on integration to overall system transformation. In other words,

BOX 3

Selected Recent Studies on Integration of High Levels Renewable Energy

- **NREL** (2012) shows relatively small rate increases over next 40 years with 80 percent renewable energy in 2050 in the U.S.
- **Univ. of Delaware** (Oct 2012) - electric system can be powered 90 to 99.9 percent of hours entirely on renewable electricity, at costs comparable to today's but only if we optimize the mix of generation and storage technologies
- **PJM** (Feb 2014) – the PJM system, with adequate transmission expansion and additional regulating reserves, will not have any significant issues operating with up to 30 percent of its energy provided by wind and solar generation

Sources: "Renewable Electricity Futures Study," NREL 2012; Cory Budischaka, DeAnna Sewell, Heather Thomson, Leon Mach, Dana E. Veron, Willett Kempton, "Cost-minimized combinations of wind power, solar power and electrochemical storage, powering the grid up to 99.9% of the time," Journal of Power Sources, Volume 225, 1 March 2013, 60–74; and "PJM Renewable Integration Study," GE Energy Consulting, February 28, 2014.

[143] "Rising Sun: Implications for U.S. Utilities," Citi Research Equities, 8 August 2013, 19-20.
[144] Carl Linvill, Janine Migden Ostrander, and Mike Hogan, "Clean Energy Keeps the Lights On," Regulatory Assistance Project, 2014.
[145] IEA 2014, 14.

simply adding large shares of renewable energy to an existing power system can be more costly and technically challenging *unless* the addition of these resources is undertaken as part of a "coordinated transformation of the entire system."[146]

Cost-effective solutions are emerging for implementing this system transformation approach. The National Renewable Energy Laboratory (NREL) identified best practices from a survey of six countries, including developing market rules that enable system flexibility (in generation, storage, and load), diversifying resources, expanding the geographic footprint of operations, and improving system operations.[147] In particular, resources such as demand response, storage, and energy efficiency are important tools complementing such a systemic transformation.

In Germany, policymakers have used some of these solutions and are examining others to address the central challenge of enhancing the flexibility of the electricity system as variable renewable generation has increased to account for over 20 percent of electricity consumption. For example, concerted efforts have been made to improve integration and coordination with neighboring markets. There is also consideration of capacity markets to enable greater flexibility in generation and to ensure security of supply, and the EEG 2.0 reforms are in part geared to address the merit-order effect of renewable energy dispatch on wholesale prices.

In Japan, the experience with renewable energy integration is not as extensive and there are several differences with Germany that pose barriers to the widespread deployment of renewable energy. These include lack of interconnection with neighboring power markets, geographic constraints (limited suitable land area for some renewable technologies), the structure of the industry, lack of competition, and higher renewable technology costs.

Nevertheless, while the share of renewable generation remains small, nearly 9 GW of renewable capacity has been added since the FIT took effect in July 2012 with no impact on reliability. Moreover, even though there is disagreement over its role in Japan, all parties recognize that nuclear power will decrease as a share of the energy mix, and the shortfall will be made up through a mixture of renewables, demand management, and fossil fuels (coal and gas). In short, although the share of nuclear power is subject to contestation, there is widespread acknowledgement that it will be less than was proposed in the 2014 Basic Energy Plan, and that renewables have an important role to play in making up that shortfall. Japan will need to assess the tools—and lessons—available to implement an approach tailored to its needs in order to achieve large shares of renewable energy in its electricity portfolio.

COSTS AND WEALTH DISTRIBUTION IMPACTS MUST BE MANAGED

Transformation of the electricity portfolio will entail costs and raise issues over who bears those costs. Indeed, renewable energy is often criticized for requiring subsidies to stimulate investment, integration costs to account for variability, and other market distortions.[148] Consequently, policymaking and market design must be carefully considered to ensure net wealth creation to the extent

[146] IEA 2014, 15.
[147] Jaquelin Cochran, Lori Bird, Jenny Heeter, and Douglas J. Arent, "Integrating Variable Renewable Energy in Electric Power Markets: Best Practices from International Experience," National Renewable Energy Laboratory, April 2012. Other best practices identified are leading public engagement particularly for transmission, and coordinating and integrating planning.
[148] For example, see Robert Bryce, "Maintaining the advantage: Why the U.S. should not follow the EU's energy policies," Manhattan Institute, February 2014.

possible and avoid large stranded assets during the societal transition away from conventional generation towards renewable energy.

In both Germany and Japan, there are growing concerns over the rising costs of renewable energy policy. Specifically, there are criticisms over the cost impact and unfair burden on residential consumers and the existing utilities, as well as concerns over broader industrial competitiveness.

Rising costs of the EEG surcharge for households in Germany while many industries remain exempt have raised criticisms not only over the added financial burden, but also over the inequity of households subsidizing industry to pay for the energy transition. However, German citizens appear ready to accept this distributional effect in order to maintain international competitiveness and, as noted, many companies have benefited from lower wholesale prices. Nevertheless, rising costs prompted vocal calls for policy changes, resulting in the EEG 2.0 in which industry will shoulder more of the cost and renewable policy will be more market-oriented to contain overall costs.

Another frequent criticism is that the FIT is a subsidy for higher income individuals to deploy expensive renewable energy installations, while the costs of the FIT are borne by lower income individuals who cannot afford the systems (or those who physically cannot install renewable technologies). Interestingly, many supporters of the *Energiewende* do not view the FIT as a subsidy.[149] Rather, those with renewable installations are "investors" who earn a return on their investment. These "investors" still consume and pay for electricity from the grid and pay an EEG surcharge in proportion to their electricity consumption. This perspective recognizes that there is some distributional effect, but that it is muted by this structure. Moreover, to the extent that lower income consumers are affected by rising prices, social policy exists to redress this situation.

German policymakers do not consider those with renewable energy installations as subsidized consumers, but rather as "investors."

Similar arguments are made with regard to the large losses incurred by the big four utilities. Several of them in our discussions expressed disbelief and anger at the "wealth destruction" among the utilities caused by government policies. For example, for coal facilities coming on-line since 2005—some in recent months—it will be very difficult to recover capital costs. As noted elsewhere in this brief, however, a variety of market factors pre-dating Fukushima and having nothing to do with renewable energy policy have played a major role in the declining financial position of the utilities. Moreover, others argue that it is more accurate to say that the energy transition has effectively redistributed revenues in the power industry and created wealth: those producing renewable energy receive more income and profits relative to the larger incumbent generators, and the TSOs have also prospered. As one *Energiewende* supporter stated: "There's always a winner and loser in these distributional policy issues." In short, in this view more renewables penetration has increased competition and utilities have not adapted their business models quickly enough to compete.

[149] There also is a strictly legal view of this question. Subsides are regulated within the EU with the goal to avoid distortions in favor of domestic industries. After reviewing the German FIT, the EU courts ruled that it is not a subsidy since there is no transfer to or from the government budget; rather, it is a transfer of funds among grid operators, consumers, and producers. Still, the policy does constitute a government-mandated procurement program.

SOLUTIONS MUST BE TAILORED TO LOCAL CONDITIONS AND INCLUDE MONITORING AND COURSE CORRECTION MECHANISMS

Policymakers should be prepared not only to monitor continually the effectiveness of policy, but also to alter the policy as technology and market conditions change. A key aspect of the experience in Germany is that policy and market design are iterative. For example, German experts in our discussions acknowledged that there were mistakes in the design and implementation of the FIT: it was not sufficiently market-oriented, nor designed with enough flexibility to respond to changing electricity market conditions and especially to declining costs of technology as deployment increased. Nevertheless, there have been several modifications in the FIT policy over time, implemented as renewable capacity reached certain levels and the costs of the renewable technologies decline. The movement toward a more market-oriented approach in the recent EEG 2.0 reforms also illustrates adaptations in policy. Japanese policy also has built-in a mandated periodic review of the FIT level as well as measures to reduce the FIT surcharge on certain categories of customers.

The level of renewable deployment in Germany is beginning to focus policymakers on a new set of market design challenges. Specifically, they are grappling with how to adapt the market to enable it to move to higher levels of renewable deployment without destabilizing the system or raising consumer costs significantly. In short, the market now needs to address how to ensure sufficient *flexibility* to accommodate even higher levels of variable renewable energy, and how to price that flexibility.

In Japan, the government is examining high-level policy changes as part of its recent comprehensive energy sector review. As a result it has developed a strategic plan to address the challenges associated with the nuclear shutdown and extensive deployment of renewable energy.

Policy course corrections and adapting markets are complex undertakings. As NREL notes in a recent analysis: "Adjusting market rules is a time-consuming and shareholder-intensive process."[150] Indeed, while the broad political support for renewable energy in Germany, described above, is highly beneficial in meeting the government's long-term renewable energy objectives, it does make managing stakeholder engagement more challenging when considering changes to policy. As one German utility representative stated: "How do you modify a policy when you have 2 million people who have invested in it?"[151]

Changing and adapting policy and market design is often viewed as indicative of a failed policy and incompatible with the need for a stable investment climate, ability to maintain reliability, and to protect consumers from price increases. This static view of policy does not acknowledge that markets, technology, and consumer behavior and preferences not only change, but also change at a much faster pace than policy. Energy policy, therefore, needs to be adaptable and dynamic. In addition, this criticism ignores the fact that innovations in policy and market design can also emerge over time, providing policymakers with new tools.

Germany is attempting to formalize a policy monitoring process as part of the *Energiewende* precisely to facilitate course corrections. The

[150] Cochran et al., "Integrating Variable Renewable Energy in Electric Power Markets," 18.
[151] Comment made in private meeting.

government has built-in policy evaluation mechanisms—using collaborative approaches and independent reviews. For example, periodic monitoring reports will be published, and the government has established several collaborative initiatives to bring together federal, state, and other stakeholders to discuss specific issues in the energy transition.[152]

Finally, policy and market design should be tailored to specific local conditions, and this is substantiated by recent assessments that describe various workable approaches across different countries.[153] While Germany demonstrates that it is technically possible to integrate large amounts of renewable capacity, and that it is possible to adapt policy and market design to deploy high shares of renewable energy, even supporters of the *Energiewende* do not believe that other countries should follow suit with exactly the same approach and recognize the enormous scope of their challenge. Japan's unique geography, location of large offshore wind assets, and a network fragmented among two frequencies require a policy approach customized to account for these characteristics.

Even with agreed consensus on national policy objectives and significant buy-in and political support for the transformation of the electricity mix, it is still necessary to monitor and adapt policy mechanisms and market design to achieve those objectives, while tailoring solutions to local conditions. Overall objectives can be constant within a country's policy framework, but the policy mechanisms and market design to achieve them can be expected to change over time based on evolving on-the-ground circumstances.

ADDRESSING TRANSMISSION AND GRID CHALLENGES IS CRITICAL

Our discussions with German and Japanese counterparts reveal a consensus that addressing transmission and grid challenges is essential for transforming the electricity sector through large renewable energy capacity additions. For example, in Germany, BNetzA and the TSOs have publicly stated—and indeed there is widespread consensus among other stakeholders—that it will be very difficult to raise renewable capacity above current levels without a major expansion of the transmission grid. In addition, other unanticipated grid-related issues have arisen as a result of high levels of renewable energy capacity being added to the grid, especially distributed generation. These include greater need for redispatch and curtailment, managing loop flows with neighboring country networks, better coordinating the *Energiewende* with EU electricity market integration efforts, and addressing the impact of frequency variations on PV installations.

Major issues in building new transmission lines are jurisdictional disputes, public opposition, cost allocation, and environmental siting. As noted, Germany also has had to deal with issues related to interconnection with several neighboring countries, and Japan is confronted with the challenge of ensuring transmission functions and costs are addressed appropriately as part of its proposed electricity sector restructuring. Japan also has to deal with these issues in a system based on two frequencies and constrained interconnections among the utilities' service territories.

[152] "Energy reforms on path to success," Federal Ministry of Economics and Technology, Federal Republic of Germany, April 2013.
[153] For example, see country case studies in Cochran et al., "Integrating Variable Renewable Energy in Electric Power Markets."

The German experience offers insight to addressing these challenges. It has developed a supportive legal and regulatory platform with a focus on stakeholder engagement, transparency, and cooperative planning amongst the TSOs, and has initiated more collaboration with its neighbors. As a TSO official indicated, at the beginning of the *Energiewende* there was skepticism that the transmission companies would be able to manage the integration of large amounts of renewable capacity, but in fact the TSOs are adapting and Germany continues to maintain a high level of grid reliability.

Several other factors are important in considering transmission policy. First, storage will play a role but not in the near-term. German counterparts stated that currently building new transmission lines and expanding or upgrading existing network infrastructure is more cost effective than storage. Even with policy support and notable progress to bring down the cost of grid-level storage technologies in Germany and elsewhere, storage is not expected to be a widely competitive option before 2020.[154] Second, governments and utilities should be careful to avoid a situation in which some new transmission capacity built to accommodate renewables becomes stranded as energy efficiency and distributed generation develop. Building transmission should be carefully coordinated and planned to take into account increased distributed generation and efficiency improvements that will reduce electricity demand.

The key lessons here are:

- large-scale deployment of variable renewable energy requires new, carefully coordinated grid strategies and added investment in transmission;
- renewable energy development must be synchronized with grid development, and market restructuring;
- more interventions are required to stabilize the system, but there are tools and solutions available to system operators;
- and there is a need to prioritize and establish formal processes for public consultation in transmission line expansion.

RENEWABLES, ESPECIALLY DISTRIBUTED GENERATION, ARE FORCING CHANGES IN UTILITY BUSINESS MODELS

Renewable energy, especially distributed generation such as rooftop solar PV, is changing the traditional utility business model. The relevance for policymakers is not only to avoid creating stranded assets in the transition to higher shares of renewable energy (as discussed previously), but also to design a regulatory approach that allows utilities to adapt and find new ways to earn revenues while meeting the emerging needs of customers.

As noted, in Germany the majority of renewables deployment has been undertaken by households, farmers, and institutional investors. The big four generation companies did not significantly invest in renewables owing to several factors. First, the utilities in the early to mid-2000s were focused on adapting to market liberalization and some did not want to rely on "politically motivated" policy support for renewable energy. Second, the utilities were accustomed to financing through their own balance sheets, which involved high capital costs for large, centralized plants. The guaranteed long-term revenue streams under the FIT lowered investment risk in renewable projects, attracting

[154] See Henry Gass, "Energy storage breakout likely after 2020—former Duke Energy chief," *E&E News Climate Wire*, 6 June 2014.

capital and lowering the return on these projects to levels unattractive to the big utilities. Returns on capital employed for renewable projects in the 5 to 9 percent range simply were not sufficient to attract investment from the large generation companies. Given these factors, the utilities now find themselves without a foothold in the renewables sector and facing an increasingly unprofitable market for conventional generation.

As a result, several of the German utilities are looking actively to change their business model. The CEO of RWE stated: "My dream, my vision is that RWE will put solar panels on your roof, a battery in your shed, a heat pump in your cellar, and we will also manage this complex energy system for you. We want to be the holistic energy manager of the future."[155] E.ON recently invested in Sungevity, a major solar company, with the intent to partner in providing customers with rooftop solar PV.[156]

In Japan, different dynamics are at play, although the resulting impact on the utilities is similar: those power companies with idled nuclear reactors are not able to generate revenues from those assets, and are spending more to buy imported fuels to maintain supply. While the discussion of future business models for Japanese utilities is not nearly as far along as in Germany and the U.S.—in large part owing to the fact that the government has been working out the details of energy policy—they certainly will be affected by the electricity sector restructuring reforms proposed by the government (see following section).

MARKETS AND INDUSTRY STRUCTURE MATTER

Closely linked to the issue of changing business models is that the transformation of electricity portfolios is taking place within different industry structures and types of market. Germany is a completely unbundled electricity sector with robust wholesale and retail markets, extensive competition, and interconnections with neighboring systems and regional markets. Japan has a regulated market dominated by vertically-integrated, monopolistic utilities, limited domestic intra-regional interconnections, and no linkages with markets beyond its borders. In addition, there is very limited competition and its wholesale power market—the JEPX—accounts for only 0.5 percent of all power generation.[157]

The presence of organized markets and the ability to interconnect markets greatly enhance the ability to integrate large shares of variable renewable energy. Specifically, organized markets provide more opportunities to adapt and craft policy and market design elements, and are more efficient in reflecting transparent pricing signals. For example, in its assessment of best practices for accommodating renewable generation, NREL stated that to develop market rules to promote flexibility "implementing solutions without organized wholesale electricity markets can be costly."[158] Operating and monitoring well-functioning markets is an ongoing challenge, however, especially as renewable energy capacity increases. For example, as noted Germany has had to establish a

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155 Karel Beckman, "The vision of Peter Terium, CEO of RWE: 'We want to be the holistic energy manager of the future,'" *Energy Post*, 7 April 2014.

156 David R. Baker, "Sungevity solar raises $70m and hints of European plans," SF Gate, 4 April 2014, http://blog.sfgate.com/energy/2014/04/04/sungevity-solar-raises-70m-and-hints-of-european-plans/.

157 Jones and Kim, "Restructuring the Electricity Sector," 14.

158 Cochran et al., "Integrating Variable Renewable Energy in Electric Power Markets," 18.

reserve power mechanism and is actively debating the need for a capacity market to complement the energy-only market.

It is also widely accepted that greater interconnection among markets and larger balancing areas are more efficient in leveraging resources and lowering overall costs. This feature has helped in the initial stages of Germany's *Energiewende*, but with higher shares of variable renewable generation in the mix, more coordination with neighboring systems and the EU market integration process in general is needed.[159]

Industry structure also plays a role as increasing competition and more market-based incentives that come with unbundling and deregulation may provide for more adaptability in accommodating variable renewable generation. Markets in which utilities make money solely by investing in infrastructure do not incentivize the development of business models or flexible systems required to facilitate a major transformation of the electricity mix.

The process of restructuring itself is a challenging endeavor for utilities, with much time and effort dedicated not only to adapting to a new way of operating with more competition, but also to undertaking time-consuming and demanding corporate organizational change. For example, several German experts indicated that the process of market liberalization in the early- to mid-2000s played a role in distracting the large utilities from focusing on the opportunity to invest in renewable energy. However, a TSO official indicated that for transmission companies there is a strong positive connection between renewable energy and restructuring: "Vertically integrated companies are much more cautious with regard to renewables, while unbundled transmission companies see renewables as a business driver."

A highly relevant issue for Japan is that it faces the challenge of integrating large levels of renewable energy while undertaking wide-ranging electricity sector reform. With unbundling comes the challenge of ensuring integrated planning and adequate investment, i.e. making sure that system planning takes place as it does in an integrated system. This is a daunting task complicated by the manner in which Japan is implementing its restructuring. Specifically, one strong critique argues that Japan is going about its market liberalization "backwards:" that one of the lessons over the past decades is to focus on the wholesale sector first, not retail.[160]

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[159] Kristi E. Swartz, "Southeast utilities, regulators 'pretty ill-equipped' to handle industry's rapid transformation," *E&E News Energy Wire*, 17 July 2014.

[160] See comments of William Hogan at: "Restructuring the electricity sector in Japan: Will it enhance energy security?" Brookings Institution event, Washington, D.C., 13 March 2014, http://www.brookings.edu/events/2014/03/13-restructure-electricity-sector-japan.

6. Implications for the United States: Renewable Energy and the National Interest

Renewable energy is an abundant resource and has been an important and growing component of the U.S. electricity portfolio in recent years (see **Box 4**). Owing largely to declines in cost and policy support at the federal and state levels, installed capacity of renewable energy has increased from 93 GW in 2000 to 163 GW in 2012, a compound annual growth rate of 4.8 percent.[161] Renewable capacity additions have grown sharply in recent years exceeding coal and nuclear additions, and in many locations renewable energy penetration surpasses 10 percent of the total electricity supply. The American Wind Energy Association indicates that wind accounted for 30 percent of all new generating capacity in the last five years; Iowa and South Dakota each now get more than 25 percent of total electricity production from wind.[162]

Cost reductions associated with economies of scale have been a major driver in the success of deploying renewable energy. The levelized cost of energy for utility-scale, onshore wind declined 23 percent in the U.S. in the period from 2009-2013, and PPA prices in 2013 in several regional markets were \$20/MWh to \$60/MWh (although higher in other regions).[163] Solar costs are also declining: Installed prices for residential and commercial PV in the U.S. have dropped an average of 5 to 7 percent per year from 1998 to 2011.[164] Utility-scale solar PV costs are decreasing and in some areas of the U.S. solar PPAs have been signed for delivery in 2015-2016 at prices between \$65/MWh to \$70/MWh.[165]

Federal and state policies both have played a vital role in promoting renewable energy. The federal production tax credit has spurred wind capacity additions, while at the state level the renewable portfolio standard (RPS) and net metering, along with a variety of other financial and regulatory mechanisms, have boosted renewable energy

[161] See NREL, "2012 Renewable Energy Data Book," 17 and 22.

[162] "American wind power reaches major power generation milestones in 2013," American Wind Energy Association (AWEA), 5 March 2014, http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=6184. AWEA also estimates that wind accounted for more than 12 percent of total electricity generation in nine states, more than 5 percent in 17 states.

[163] "Sustainable Energy in America Factbook," *Bloomberg New Energy Finance (BNEF)*, February 2014, pp. 38-39 (BNEF 2014). This estimated range is for ERCOT in Texas, Midcontinent Independent System Operator (MISO), PJM, and the Southwest Power Pool (SPP). For reference, the wholesale spot electricity price in the U.S. in mid-2013 ranged from \$35-65/MWh; see U.S. Energy Information Administration at http://www.eia.gov/todayinenergy/detail.cfm?id=12211.

[164] "Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-term Projections," Sun Shot Initiative, U.S. Department of Energy, November 2012, 2-3.

[165] *BNEF,* "Sustainable Energy in America Factbook," 35.

BOX 4

Renewable Energy in the U.S. Power Sector: Potential and Milestones

- NREL has identified potential for renewable technology in nearly every state—totaling possibility to generate 481,800 tWh, more than 100 times total U.S. electricity consumption in 2011.
- A national record was established in May 2013 in Colorado when wind reached over 60 percent of total generation.
- For the first time in September 2012, all new capacity added in the U.S. was from wind and solar.
- On March 8, 2014, California set a state record with solar energy meeting 18 percent of total demand, or 4.1GW

Sources: Anthony Lopez, Billy Roberts, Donna Heimiller, Nate Blair, and Gian Porro, "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis," NREL, July 2012; "Xcel reveals winds of change," Kathleen Wolf, Intelligent Utility, July 24, 2014; "Energy Infrastructure Update – September 2012," Office of Energy Projects, Federal Energy Regulatory Commission; "California's grid sets two new solar energy records in two days," Clean Tecnica, March 13, 2014.

deployment, especially wind and solar.[166] In addition, 34 states have completed Climate Action Plans and 20 states have GHG emissions targets.[167] In the case of California and the Regional Greenhouse Gas Initiative (RGGI) in the Northeast, a cap-and-trade system is employed to place a price on carbon.

Despite this progress—and clear evidence of growing shares of renewable energy in many locations—some observers remain skeptical if not strongly critical of renewable energy, citing Germany and Japan's move away from nuclear power and targeting large-scale deployment of renewable energy as misguided or failed policy.[168] Indeed, several of the same themes and issues emerging in Germany and Japan are evident in the United States. However, the challenges confronted by Germany and Japan should not lead policymakers to discard or disparage renewable energy as an important part of the electricity mix. We believe that the findings and lessons described in the previous chapter illustrate important implications for policymakers in the United States looking to craft energy policy; specifically, the experience of Japan and Germany offers ways in which the U .S. can transform the electricity portfolio as a critical component in addressing climate change. These lessons illustrate key areas that U.S. policymakers should address to ensure a smoother transition to large-scale deployment of renewable energy.

FIRST*, *policymakers must work to build a baseline consensus on national energy objectives and then develop and implement durable, consistent, and clear policy mechanisms to achieve those objectives. In the United States, there historically has been much less consensus on how to balance security, economic, and environmental goals in energy policy than in Germany and Japan.[169] Specifically, the discussion about advantages and disadvantages of renewable energy as a key part of the electricity mix has been submerged in several

[166] According to the Database of State Incentives for Renewables and Efficiency (DSIRE), 29 states and the District of Columbia have an RPS, and 43 states and the District of Columbia have a net metering policy. See http://www.dsireusa.org/.

[167] See Center for Climate and Energy Solutions, http://www.c2es.org/us-states-regions.

[168] U.S. Senator Dan Coats, "What Obama could learn from Germany's failed experiment with green energy," *Fox News,* 5 June 2014, http://www.foxnews.com/opinion/2014/06/05/what-obama-could-learn-from-germany-failed-experiment-with-green-energy/. See also, Bryce, "Maintaining the advantage."

[169] Since the U.S. uses no imported fuels in the electricity sector, security defined as reducing dependence on imported fuels is not a major factor in this sector. However, continued reliance on fossil fuels does have national security implications in terms of climate change, as identified by the U.S. Departments of Defense and State.

dynamics resulting in inconsistent national policy support.

In the electricity sector, the institutional and regulatory structure governing the industry—with 50 state regulatory commissions along with an overlay of regional quasi- regulatory bodies and the Federal Energy Regulatory Commission (FERC), as well as varied markets and regional resource endowments—presents major obstacles for the development and implementation of cohesive national policy.

In addition, complicating the discussion over objectives is a long-standing debate over the role of the government. Policymakers have struggled to agree on the right way—if any—for the government to influence or participate in the market. Specifically, what is the right policy mix along a spectrum from market-based to command-and-control approaches? In recent years, this debate has been exacerbated by the economic recession, generating criticism about government spending, wasteful subsidies, and "picking winners," especially government support for renewable energy.

This view was recently reflected in the comment of FirstEnergy's CEO that government "interference" is the most significant disruptor for the utility industry.[170] In addition, there has been a burgeoning campaign by some groups to repeal state-level renewable portfolio standards and amend significantly net metering rules, with claims that these policies raise rates for consumers, hurt the economy, kill jobs, and serve selected vested interests.[171] Nevertheless, while not as far along as Germany, there is a burgeoning renewable constituency in the U.S. which has been able to push back against these efforts.[172]

The hydrocarbon boom in the United States also has complicated the formation of energy policy. Skyrocketing production of natural gas and oil made possible by hydraulic fracturing and horizontal drilling has created jobs and stimulated economic growth. Natural gas prices have been at historic lows impacting the competitiveness of other fuel sources such as nuclear power, coal, and renewables. Cheap natural gas also has helped lower CO_2 emissions by displacing coal-fired generation. The short-term economic benefits of oil and gas development have shifted attention away from longer term environmental goals, especially addressing climate change.

Finally, there is much less agreement in the U.S. on the science and impacts of climate change. Despite the *Energiewende's* costs, German households and politicians remain ideologically committed to the goal of emissions reduction and highly tolerant of the associated costs. The fact that concern over climate change and its impacts has not penetrated American politics or society in the same way may be the most significant cultural difference between the two countries. This difference could also explain the American disbelief that Germans can support such a policy despite increasing consumer costs.

As a result of these dynamics, energy policy in the U.S. is more fragmented and inconsistent. Federal policies supporting renewable energy emphasize selected financial incentives such as production and investment tax credits, loan guarantees, grants, and other similar programs. These mechanisms, funded by taxpayers, focus on reducing the high

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[170] Anthony Alexander, "Government policies are impacting electric service," FirstEnergy, 8 April 2014, http://www.firstenergycorp.com/content/fecorp/newsroom/featured_stories/AJA-Chamber-Speech.html.

[171] Evan Halper, "Koch brothers, big utilities attack solar, green energy policies," *Los Angeles Times*, 27 May 2014. A recent analysis by NREL and LBNL, however, concluded that the state RPS did not have a large impact on retail electricity rates: from 2010-2012 RPS compliance costs were the equivalent of 0.9 percent of retail rates. See J. Heeter, G. Barbose, et al., "A Survey of State-level Cost and Benefit Estimates of Renewable Portfolio Standards," National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory, May 2014.

[172] Steven Mufson and Tom Hamburger, "A battle is looming over renewable energy, and fossil fuel interests are losing," *Washington Post*, 25 April 2014.

up-front capital costs of deploying the renewable technologies, but are subject to the short-term boom and bust political approval process in Congress.[173]

As noted, however, states are also important leaders in energy policy and indeed many experts consider them to be important policy "laboratories." In fact, the German FIT implemented at the national level as part of the EEG in 2000 was inspired by local municipal feed-in programs in Hammelburg, Freising and Aachen.[174] Thus, efforts below the national level can and do serve as valuable proving grounds for viable policy approaches.

Nevertheless, our research for this project, as well as over the past several years, indicates the importance of a national energy-climate policy. Building a perfect consensus on energy objectives is likely unachievable, but constructing a minimal or baseline consensus is required. A wide variety of stakeholders, including in the private sector, prefer this approach since it provides "policy durability," a more predictable investment climate; better matches utility planning cycles; and provides the business certainty needed to stimulate the economy.[175]

SECOND, the U.S. needs to elevate environmental goals as part of its overall energy objectives—in particular addressing climate change through reduction of GHGs—and link these environmental goals to economic and national security issues.

Skepticism about climate change and its impacts is a major factor impacting the debate over energy policy in the United States. In the past year, the U.S. government has intensified efforts to highlight climate change as a critical national policy issue.[176] The White House unveiled a *Climate Action Plan* in June 2013 outlining three ways to address climate change, including reducing carbon emissions from power plants.[177] The latter is viewed as critical given the lack of congressional action to address climate change, and that the power sector accounts for 40 percent of total U.S. CO_2 emissions. In March 2014, the Department of Defense's *Quadrennial Defense Review 2014* concluded that the impacts of climate change are "threat multipliers."[178] In May, the Global Change Research Program released the *National Climate Assessment*, concluding that the U.S. is already experiencing the impacts of climate change from drought, severe weather, ocean acidification, and sea level rise.[179] Then on June 2, 2014, the EPA issued its proposed rules to reduce carbon emissions from existing power plants by 30 percent by 2030.[180]

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173 Jesse Jenkins, Mark Muro, Ted Nordhaus, Michael Shellenberger, Letha Tawney, and Alex Trembath, "Beyond Boom and Bust: Putting Clean Tech on a Path To Subsidy Independence," Brookings Institution and Breakthrough Institute, 18 April 2012, http://www.brookings.edu/research/papers/2012/04/18-clean-investments-muro.

174 Hans Josef-Fell, "Feed-in tariff for renewable energies: An effective stimulus package without new public borrowing," April 2009, p. 5, http://hans-josef-fell.de/content/index.php/dokumente-mainmenu-77/doc_download/26-feed-in-tariff-paper.

175 John P. Banks, Jeremy Carl, Kevin Massy, Pedram Mokrian, Jelena Simjanovic, David Slayton, Amy Guy Wagner and Lisa V. Wood, "Assessing the Role of Distributed Power Systems in the U.S. Power Sector," Brookings Institution and Hoover Institution, October 2011, http://www.brookings.edu/research/papers/2011/10/distributed-power-systems

176 Other institutions also have raised the importance of climate change as a major public policy issue: see the American Academy for the Advancement of Science, and the National Academy of Sciences.

177 "President Obama's Climate Action Plan," Executive Office of the President, U.S. Government, June 2013, http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

178 "Quadrennial Defense Review 2014," U.S. Department of Defense, March 2014, p. 8. Specifically, it concludes that the impacts of climate change are "threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions—conditions that can enable terrorist activity and other forms of violence." The Department of State and National Intelligence Council have made similar findings.

179 Jerry M. Melillo, Terese (T.C.) Richmond, and Gary W. Yohe, eds., *Climate Change Impacts in the United States: The Third National Climate Assessment*, U.S. Global Change Research Program, 2014, http://nca2014.globalchange.gov/.

180 "Clean Power Plan Proposed Rule – June 2," EPA, 2 June 2014, http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule.

This is welcome progress, but these efforts must be sustained in order to construct a baseline consensus on energy policy going forward. In particular, policymakers and society at large need to view climate change not just as a strictly environmental issue, but also as economic and national security issues. In particular, the economic benefits of responding to climate change are vastly underplayed. Not only can energy-climate policy help improve the international competitiveness of domestic industries, but it also serves as a hedge against the potentially huge economic cost of climate-related impacts on coastal areas, agriculture, infrastructure, and other areas.

Indeed, there are signs that the economic and national security linkages may work to bring all parties to the table to work out an acceptable policy.[181] For example, four former Republican administrators of the EPA recently testified on the importance of addressing climate change.[182] Several prominent conservative economists have voiced support for a carbon tax, focusing on how it could serve as a revenue generator in times when new sources of revenue are hard to come by. Alternatively, some have argued for a revenue-neutral carbon tax with revenues used to provide tax relief in other areas (e.g., payroll and corporate taxes).[183] While there remains considerable opposition to a carbon tax, the fact that there is more discussion of this policy tool is encouraging.

Reducing the use of fossil fuels goes beyond carbon. Fossil-fuel fired plants in the U.S. power sector account for 60 percent of all sulfur dioxide (SO_2) emissions, 46 percent of all mercury, and contribute to emissions of nitrogen oxides (NO_x) and particulate matter (PM_{10}).[184] These pollutants have major economic ramifications: the National Academy of Sciences estimated damages from emissions of SO_2, NOx, and PM_{10} from coal and natural gas generation facilities approached $63 billion in 2005.[185] Thus, the emphasis on environmental goals needs to incorporate a range of pollutants beyond carbon dioxide.

THIRD, renewable energy needs to be considered a national asset, with the capacity to balance multiple objectives. Elevating the environmental component in energy policymaking does not mean dismissing or decreasing the importance of the other traditional objectives. Rather, as Germany—and increasingly the U.S.—have shown, transforming the electricity mix by deploying high levels of renewable energy as a low-carbon source of electricity is not only possible, but is also an effective, viable, and increasingly affordable tool in meeting environmental, economic, and national security goals.

However, there are cautionary lessons from the *Energiewende* in Germany and to a lesser extent Japan. Large shares of renewable energy in the electricity mix require a coordinated transformation of the entire electricity sector entailing a high level of planning as well as the use of other resources, both on the supply and demand side. Policy needs to be able to address costs and issues of equity, be market oriented, adaptable and

[181] Anne C. Mulkern, "Action on warming likely in short term, some Republicans say," *E&E News*, 20 May 2014. The devastating economic impact of Hurricane Sandy plays a part in this dynamic; see Samantha Lachman, "GOP Rep. Michael Grimm decides climate change is real after actually looking at the research," *Huffington Post*, 25 April 2014. Rep. Grimm represents Staten Island which was very hard hit by Hurricane Sandy.

[182] Jean Chemnick, "Republican former EPA administrators set to testify on warming," *E&E News*, 16 June 2014.

[183] Evan Lehmann, "Former Reagan official predicts Republican skeptics will be 'mummed' by climate change," *E&E News* ClimateWire, 14 July 2014.

[184] "Clean Energy Standards: State and Federal Policy Options and Implications," Policy Discussion Paper, The Regulatory Assistance Project and The Center For Climate And Energy Solutions, November 2011, www.c2es.org/docUploads/Clean-Energy-Standards-State-and-Federal-Policy-Options-and-Implications.pdf.

[185] "Hidden Costs of Energy: Unpriced consequences of energy production and use," National Research Council of the National Academies, 2010. NOx emissions from the power sector accounted for 13 of all emissions, and PM_{10} accounted for 4 percent.

geared toward creating "investors" or "constituents" across a wide swath of society. Policy should promote flexible markets and ensure that a comprehensive approach to transmission and grid integration is in place. In addition, policymakers need to avoid the creation of large stranded assets and foster regulatory approaches that allow utilities to pursue new business models.

Some of these challenges are already evident in the United States. Cost and distributional equity concerns have emerged with critics claiming that net metering is placing an unfair burden on those who do not deploy solar rooftop PV. Some utilities also argue that the success of net metering in stimulating the deployment of solar rooftop PV—along with technological innovation and the emergence of new market entrants—threatens their revenues by not allowing them to recover costs for investment in infrastructure. There have been several notable attempts to fine tune or alter existing policy to address these issues. For example, Austin Energy and the state of Minnesota have developed a value of solar tariff as a mechanism to better incorporate all the costs and benefits of solar rooftop PV. More importantly, the dynamics surrounding the growth of distributed energy have stimulated a debate over the future of electric utilities, and possible new business models.[186]

The U.S. is also grappling with challenges related to industry structure and the operation of markets, especially in light of increasing renewable energy capacity. First, the U.S. has a highly complex industry comprised of varied ownership types, structure, and markets depending on geographic location. As one storage developer noted to us several years ago: "Rules are different across 39 different balancing authorities and 50 states; it's confusing and not uniform."[187] Second, depressed wholesale prices are causing some utilities to view the regulated side of the business more favorably (to ensure cost recovery as their capital expenditures increase). The existing regulatory model, however, does not provide the flexibility and incentives for utilities to adapt their business models to enter new markets, such as distributed generation. As a result, a few states have begun the process of examining ways to change the existing regulatory model to allow utilities to seek new opportunities in meeting evolving customer needs.[188]

Organized markets, such as PJM, have had success in integrating new tools such as capacity markets, demand response, and energy efficiency, all considered valuable complementary resources in facilitating renewable energy integration. There are also initiatives to create new markets: in June, FERC approved the formation of an energy imbalance market linking energy resources in California, Oregon, Washington, Utah, Wyoming, and Idaho.[189] Nevertheless, there are others who believe that the organized markets in the U.S. are not functioning well and need major adaptations to accommodate higher shares of renewable energy, especially in light of EPA's proposed CO_2 rules for existing power plants.[190]

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[186] See John P. Banks and Charles K. Ebinger, "The Electricity Revolution," Brookings Institution, October 2013, www.brookings.edu/research/reports/2013/11/06-electricity-revolution-ebinger-banks.

[187] John P. Banks, et al., "Assessing the Role of Distributed Power Systems," 63.

[188] For example, the public utility commissions in New York and Hawaii have initiated efforts to revamp the existing regulatory compact. For New York, see New York State Public Service Commission, "Reforming the Energy Vision (REV)," New York State Government, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/26BE8A93967E604785257CC40066B91A?OpenDocument; for Hawaii see Public Utilities Commission, "Commissions Inclinations on the Future of Hawaii's Electric Utilities," State Government of Hawaii, http://puc.hawaii.gov/wp-content/uploads/2014/04/Commissions-Inclinations.pdf.

[189] Hannah Northey, "Regulators OK novel plan for 'real time' power sharing in the West," *E&E News*, 19 June 2014, http://www.eenews.net/stories/1060001626.

[190] See for example: "Markets matter: Expect a bumpy ride on the road to reduce CO_2 emissions," Navigant, May 2014.

In transmission, some of the issues identified in Germany and Japan also are present in the United States. FERC Order 1000, intended to streamline transmission planning and address cost allocation, has run into state-federal jurisdictional questions, and local opposition to transmission line construction remains problematic. However, several state initiatives also are underway that address planning and public consultation issues, including the Competitive Renewable Energy Zones (CREZ) in Texas, and the Renewable Energy Transmission Initiative in California.[191] The CREZ is credited with facilitating the addition of 3,500 miles of transmission lines and reducing curtailments of wind generation since 2011.[192]

In terms of policy monitoring and adaptation, several prominent organizations in the U.S. have proposed similar mechanisms to those in Germany. The American Energy Innovation Council calls for the creation of an independent National Energy Strategy Board charged with developing and monitoring a national energy plan for Congress and the executive branch, as well as "guiding and coordinating energy research investments by DOE" and other programs.[193] The Bipartisan Policy Center recommends the establishment of a National Energy Security Council to develop a national energy strategy and a commensurate implementation plan that would include "tracking and reporting progress." [194]

Even with renewable energy playing a key role in the electricity mix to help meet a broad range of objectives, this does not mean that policies should emulate those in other countries. For example, cultural, economic, and industry differences between Germany and the U.S. mean that we cannot expect every element of the *Energiewende* to work in the US. For example, the FIT is not likely to be a policy tool widely deployed in the United States.[195] As part of Brookings's research in recent years we have heard considerable skepticism of the FIT among key stakeholders, with concerns largely revolving around the experience with the Public Utility Regulatory Policies Act (PURPA).[196] Abundant, cheap natural gas also seems to offer one low-cost and politically palatable pathway to reduce carbon emissions significantly (i.e., a widely available alternative to coal), though over-reliance on natural gas brings its own set of challenges, largely revolving around future price volatility and environmental implications. In addition, electricity consumption of the average American household is significantly greater than the average German family of four which uses about 3,500 kWh/year, while the U.S. average is 10,800 kWh/year, making a U.S. ratepayer much more sensitive to price increases.[197] At a minimum, if the U.S. were to experience a widespread rate increase due to higher renewable energy penetration, American industry would likely shoulder most of the burden, unlike German industry. Finally, as noted, amongst the general populace in Germany there is considerably more agreement than in the U.S. on the importance of addressing climate change and, commensurate with that, support for the renewable energy policy and the costs associated with implementing it.

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[191] For more on these see Cochran et al., "Integrating Variable Renewable Energy in Electric Power Markets," and also "US-German Clean Energy Leadership Series," Center for Climate and Energy Solutions and Ecofys Consultancy, vol. 1, November 2013.
[192] "Fewer wind curtailments and negative power prices seen in Texas after major grid expansion," Today in Energy, EIA, U.S. Government, 24 June 2014.
[193] "A Business Plan for America's Energy Future," American Energy Innovation Council, September 2011.
[194] "The Executive Branch and National Energy Policy: Time for Renewal," Bipartisan Policy Center, November 2012, 21.
[195] "Feed-in tariff: A policy tool encouraging deployment of renewable electricity technologies." Today in Energy, EIA, U.S. Government, 30 May 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=11471.
[196] John P. Banks, et al., "Assessing the Role of Distributed Power Systems," 68-69.
[197] See EIA, "How much electricity does an American home use?" http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3.

In sum, ignoring the lessons identified in this brief is unacceptable: we risk discrediting renewable energy and thereby losing a critical component in combating global climate change, with attendant national security and economic implications. Renewable energy is certainly not the only option for the electricity portfolio. Nevertheless, despite the challenges, renewable energy is a critical national asset, providing a viable, increasingly cost-competitive option to lower carbon emissions, bolster the economy, create a globally competitive industry, and strengthen national security. U.S. policymakers, industry officials, consumers, and other stakeholders need to view energy-climate policy in this light, and understand the potential for large shares of renewable energy to meet these multifaceted and interrelated goals.

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