The winds of change: How wind firms assess Germany's energy transition

Karen Smith Stegen & Matthias Seel*

This is an Accepted Manuscript of an article published by Elsevier in the journal Energy Policy on 26 July 2013, available online: http://www.sciencedirect.com/science/article/pii/S030142151300637X.

To cite this article: Karen Smith Stegen & Matthias Seel (2013): The winds of change: How wind firms assess Germany's energy transition. Energy Policy, 61, 1481-1489.

Abstract

In September 2010 the German government initiated a plan to shift from fossil fuels to renewable energies, with nuclear power as a bridging fuel. Following the Fukushima nuclear disaster, however, the government decided to immediately shut down almost half of Germany's reactors and phase out the rest by 2022. The outcome of Germany's energy transition (*Energiewende*) from high-carbon and nuclear sources of power to renewable energies has implications for Germany's prosperity and may serve as either a positive or negative model for other countries. Achieving the Energiewende will require the commitment of Germany's renewable energy companies, whose opinions on the transition have not yet been reported. This article seeks to help fill this gap by relating the views of over 80 percent of Germany's wind industry, per market share. The firms in our study are mostly optimistic about the government's ambitious targets, but express concern over the prospects for offshore wind, lagging network expansion, and the efficacy of extant legislation to support the transition. From the government's side, cost concerns have already led to discussions of slowing the transition, leading to a *push–pullback* policy approach. For the transition to proceed smoothly, fundamental issues, such as market design, must be resolved.

Keywords: Energy transition, Renewable energy, Wind energy

* Corresponding author. Tel.: +49 4212004873; fax: +49 421200494873. E-mail addresses: k.smithstegen@jacobs-university.de (K.SmithStegen), ms4560@columbia.edu (M.Seel).

[page 1481]

1. Introduction

In September 2010 the German government rolled out an ambitious long-term initiative to fundamentally decarbonize its energy practices and portfolio by shifting from fossil fuels to renewable energies, with nuclear power serving as a bridging fuel. Six months later, on the heels of the Fukushima nuclear disaster, German politicians – led by chancellor and physicist Angela Merkel – abruptly shut down eight of Germany's 17 nuclear plants and, several months later, decided to completely phase out nuclear energy by 2022. The German government kept the far-reaching goals of its energy plan as launched in 2010, but now intends to effect the “Energiewende” (energy transition) without nuclear power. As Germany is one of the most industrialized countries in the world, the notion of decarbonizing without nuclear power – and the risks this might pose to its manufacturing sector – grabbed international headlines. If Germany is successful, it could pave the way for other countries to follow; however, if it fails, then other countries may be reluctant to undertake similarly ambitious environmental and energy goals (Fischer and Geden, 2011 and Westphal, 2012). The stakes are high.

Although the decision to transition away from fossil fuels and nuclear power is a recent one, we posit that it is the culmination of three historical trends in German politics and culture. First, Germany has long been environmentally progressive, which is particularly exemplified by its leadership in international climate change talks. In 1995, for example, Germany announced highly ambitious reduction

[page 1482]

targets for CO_2 emissions, which helped rejuvenate international negotiations. At the Kyoto Summit in 1997, Germany agreed to the largest emissions reductions within Europe.

Second, the German government has strongly supported the development and deployment of renewable energies. Over 20 years ago the government introduced the first feed-in tariff (FIT), a mechanism that guarantees a minimum purchase price for electricity from renewable sources entering the national grid. In 2000 Germany promulgated the Renewable Energy Act (the Erneuerbare Energien Gesetz, or EEG), which, among other pro-renewable energy stipulations, provides renewable electricity with priority access to network infrastructure.

Last but not least, German citizens have long been wary of nuclear power and nuclear waste storage. During the 1970s, for example, massive protests against nuclear power succeeded in halting the construction of a nuclear power plant. Then, the Chernobyl nuclear accident in 1986 solidified public opinion against nuclear power and the first plans to phase out nuclear energy were undertaken in 2000, when the maximum lifespan for each nuclear plant was set at 32 years, resulting in an overall phase-out by the year 2021. Although this lifespan was briefly extended in 2010, the much-heralded nuclear exit of 2011 is for all intents and purposes a resumption of the earlier plans, with 2022 as the termination date.

The Energiewende is comprehensive in that it sets broad environmental and energy use targets, ranging from emissions reductions to conservation and efficiency through to the national energy mix itself. But the Energiewende does not treat all aspects equally. Transportation issues, for example, have been underemphasized (Röhrkasten and Westphal, 2012). The primary focus of the Energiewende seems to be on electricity generation—to the point that one could say the energy transition is actually an *electricity transition*. According to the German government's plans, renewable energies, particularly wind, should become the primary sources of electricity, supplying 80 percent of gross electricity production by 2050.

The initial reaction to the Energiewende ranged from cautious enthusiasm to jubilation, particularly by anti-nuclear and environmental activists. Recently, however, a more pessimistic and cautionary tone can be heard. For example, the head of Germany's Monopolies Commission related to the *Frankfurter Allgemeine Zeitung*, Germany's premier newspaper, that “a tsunami of costs is approaching German citizens” (Haucap, 2012). In an early 2013 interview with the same newspaper, Germany's environmental minister, Altmaier (2013), estimated that the Energiewende would cost a trillion Euros. More moderate voices, however, contend that these costs are exaggerated and Altmaier has been called “irresponsible” to cite such a high figure without supplying any underlying calculations (Uken, 2013). In short, whether the Energiewende will ruin Germany or bring it long-term prosperity by establishing its renewable energy leadership is hotly debated.

Although news media around the world have taken an interest in Germany's Energiewende, little has been written in scientific journals, perhaps because it is still such a new phenomenon. In 2010, the German government tasked several major research institutions – the Fraunhofer Institute, the German Center for Aerospace, and the Engineering Bureau for Energies – with developing long-term scenarios for the expansion of renewable energies (Nitsch et al., 2012). Several prominent German think tanks have published reports and articles on the Energiewende and its implications, particularly regarding its potential as a model for other countries and regions (see Fischer and Geden, 2011, Röhrkasten and Westphal, 2012 and Westphal, 2012). Economists have also taken great interest, particularly in the market, regulatory and

pricing dimensions (see Brandstätt et al., 2011, Pfaffenberger and Chrischilles, 2013 and Menges and Pfaffenberger, 2012).

The perspective that we feel has thus far been missing from the literature is that of Germany's renewable energy companies. As these companies are expected to lead the transition – on the ground – we believe they offer an intriguing vantage point from which to gauge the German government's plans. In 2012 we asked the largest wind companies in Germany to assess the Energiewende and identify the main challenges. In this article, we present key facets of the Energiewende, particularly those involving wind energy, interwoven with the viewpoints of wind companies and background material on Germany's energy situation. We close by analyzing the government's approach, pinpointing several key underlying issues, and discussing the implications.

2. Methodology

The wind industry in Germany comprises about 15 companies; some primarily manufacture turbines and others are both producers and project developers of wind farms. In terms of manufacturing, the market is dominated by eight businesses, which in 2012 held a market share of 97 percent measured by capacity. Producing 42 percent of Germany's wind turbine capacity, Enercon was the largest company, followed by Vestas (27 percent), GE Energy, Nordex and REpower (7 percent each), Siemens (5 percent), Fuhrländer (2 percent), and Bard Holding (<1 percent) (Fraunhofer Institut für Windenergie und Energiesystemtechnik, 2013).

Vestas was founded in Denmark in 1979 and has emerged as the world's leading supplier of wind turbines with a global market share of 20 percent. The company focuses on the supply and construction of wind turbines and is not particularly active as a project developer. The world's second largest wind turbine producer is German-based Enercon, which operates in over 30 countries and, under UEE Holding GmbH, is involved in project development.

Of the other companies founded in Germany – Nordex, Repower, Siemens, Fuhrländer and Bard Holding – only Siemens can be classified as a major international player, currently ranking ninth in the world market. Nordex, Fuhrländer and Bard Holding predominantly focus on the German market with some engagement in other European countries. A few of these companies are also project developers.

While founded in Germany, in 2007 REpower was acquired by the Indian wind power company Suzlon Energy. The company provides turbines for both the onshore and offshore markets and constructed the first German offshore wind park, alpha ventus. Through subsidiaries and joint ventures, REpower is predominantly active in the European, North American and Chinese markets.

GE Energy is a subsidiary of the US-based General Electric company. Through its association with its parent company, GE Energy is internationally active in both construction and project development. Recently, GE Energy has also started to supply offshore wind turbines.

To evaluate the perceptions of these companies, we created a 38-question survey. Twenty-four of the questions were multiple choice, 11 offered scaling response options, and three asked participants to rank different answers according to their importance. The survey was sent to all eight wind companies in the list above. Five of the eight responded, a response rate of 62.5 percent. Each of these five firms is both a turbine manufacturer and a project developer. To provide their exact total market share would too easily allow their identities to be discerned, but it comprises over 80 percent of the German market. Three out of the five firms are active only in onshore wind energy and two are active in both onshore and offshore. Due to assurances of anonymity, neither the names of companies that returned the questionnaire nor the answering patterns for specific companies will be disclosed.

[page 1483]

3. The Energiewende goals

3.1. General goals

The German government's energy plan sets goals in multiple arenas. Greenhouse gas emission targets call for a 40 percent drop by 2020, 55 percent by 2040, and 80 to 95 percent by 2050 (compared to 1990 levels). Energy consumption should decrease 20 percent by 2020 and 50 percent by 2050 (compared to 2008 levels). Building insulation rates should double. The transportation sector should also dramatically increase its efficiency and reduce its energy consumption 10 percent by 2020 and 40 percent by 2050. Chancellor Merkel has declared that, by 2030, there should be 6 million electric vehicles on German roads (Nitsch et al., 2012).

In tandem with these changes, renewable energies should become the predominant sources of electricity, by 2020 comprising at least 35 percent of the German gross electricity production. In 10 year increments, this minimum share should be increased to 50 percent (by 2030), 65 percent (by 2040) and, by 2050, to 80 percent (Bundesregierung, 2012). Coupled with a scheduled 25 percent decrease in gross electricity consumption by 2050, renewable energies would have to supply some 380 Terawatt hours (TW h) of electricity, as compared to the 136 TW h they actually did supply in 2012 (Arbeitsgemeinschaft Energiebilanzen e.V., 2013).

In contrast to these goals, in recent years Germany's real electricity mix has looked quite different. In 2012, German electricity was sourced 45 percent from coal, 16 percent from nuclear power, 11 percent from natural gas, and 5 percent from other

nonrenewable sources. Renewable energies supplied 22 percent of Germany's electricity (Arbeitsgemeinschaft Energiebilanzen e.V., 2013).

Without nuclear power as a bridging fuel, Germany will rely on new coal and natural gas plants in its transition to renewable energies (BMU, 2012). Per the government's plans, by 2020 nuclear power should be largely phased out and the capacity of renewable electricity sources should be more than twice that of coal. Throughout the past 10 years, Germany has mostly been a net electricity exporter: Although the volume of electricity exports decreased in 2011 due to the sudden closure of nuclear plants (resulting in net imports between May and September), Germany exported electricity throughout the year 2012 (Nickel, 2012).

The wind companies contacted for this study were asked how realistic they deemed the goals of replacing current conventional electricity sources with renewable energies. On a five-point scale ("completely unrealistic", "seemingly unrealistic", "partly unrealistic/realistic", "seemingly realistic", "completely realistic"), one of the larger companies (by market share) denounced the plans as "completely unrealistic"; one small and one larger company opted for the neutral "partly unrealistic/realistic", and two smaller companies responded positively with "seemingly realistic". This spread of responses indicates a somewhat weak consensus that the overall electricity goals of the Energiewende could be accomplished. Viewed in terms of the companies' market share, however, there was an almost even break between those who saw the goals as achievable and those who did not.

3.2. Wind energy targets

Since the early 2000s, German wind energy capacity has almost quintupled, with onshore and offshore capacity in 2012 amounting to 31,156 Megawatt (MW) (Fraunhofer Institut für Windenergie und Energiesystemtechnik, 2013). In 2012, the state of Lower Saxony held the largest share with more than 7250 MW, followed by Brandenburg with 4800 MW and Saxony-Anhalt with 3750 MW. Because of their limited usable land, the city states of Bremen, Hamburg and Berlin had the lowest wind capacity.

Under the current Energiewende plans, wind energy will play the most significant part in expanding the capacity of renewable energies, followed by photovoltaic. Wind energy production should grow to 45,000 MW by 2020, 65,000 MW by 2030, 80,000 MW by 2040, and 85,000 MW by 2050 (Wallasch et al., 2011). Returning to our five-point scale, we asked the German wind firms how doable they found the goal of achieving 45,000 MW capacity by 2020 and the long-term goal of generating half of Germany's electricity by 2050. None of them responded negatively to either question. Three companies saw the 2020 goal as "completely realistic" and two opted for the ambivalent "partly unrealistic/realistic". Even more positively, two companies saw the 2050 goal as "completely realistic," two others viewed it as

“seemingly realistic”, and only one opted for the middle value of “partly unrealistic/realistic”. Thus, the respondents were more upbeat about the government's specific targets for wind energy than they were about the more general targets for supplying Germany's electricity through renewable sources.

At the moment, wind energy output can be expanded in one of three ways: constructing onshore turbines in new locations; replacing older onshore turbines with new turbines, called “repowering”; and erecting turbines offshore in the North and Baltic Seas. Although our respondents' outlook regarding the overall goals for wind energy was predominantly positive, they did not view the specific prospects for offshore turbines, new onshore locations, and repowering as equally bright.

All of the wind firms in our survey were highly optimistic about the potential of onshore turbines in new locations to contribute to Germany's wind energy buildout, answering either 6 or 7 on a seven-point scale, where 7 stood for “very high potential”. Of the 16 German states, seven were selected as offering some degree of potential for onshore development (for both new locations and repowering). North Rhine-Westphalia topped the list; Lower Saxony, Brandenburg, Schleswig-Holstein, Rhineland-Palatinate, and Bavaria all shared second place; and Baden-Württemberg was third. None of the remaining nine states was selected.

In 1990, the capacity of a newly constructed onshore wind turbine was about 0.2 MW. In the meantime, technological improvements such as larger rotor blades, higher towers and more efficient transformers have made it possible to greatly increase the capacity of a single onshore turbine to as much as 7.5 MW, allowing significant capacity gains to be reaped by “repowering” existing locations. In Germany, it is estimated that over 10,000 turbines constructed before 2002 are suitable for repowering (Wallasch et al., 2011). Using the same scale as above, our respondents again showed optimism for the development potential of repowering, with three firms selecting the highest score of 7 and the other two choosing 4 and 5.

Despite their positive views on the potential of new turbines and repowering, this did not extend to the targets for offshore wind. The German government has proposed offshore capacity achieve 10,000 MW by 2020 and attain capacity even as high as 30,000 MW by 2030 (Bundesgegierung, 2013)). The largest company in our survey deemed these goals “completely unrealistic”; three companies, including one with offshore experience, opted for “seemingly unrealistic”; and only one, which is engaged in the offshore industry, believed the goals were “seemingly realistic”. This critical evaluation of the government's goals is on par with a recent report by Nitsch, (2013), co-author of the federal government's 2010 renewable energy pilot study, who deems 6500 MW as a more realistic figure. The main reasons for his lower estimate are the technological challenges, which cause higher costs for offshore windfarms, and delayed grid expansion—issues that were also repeatedly mentioned by our respondents.

On balance, our survey answers reveal that most of the participants find the government's goals for wind energy to be realistic. While this conveys a positive view of the Energiewende,

[page 1484]

the targets are only one aspect of the energy transition and should not be confused with the main driver of change: the legislation that will push industry and households to undertake the steps necessary to attain the goals. In the next section, we report and discuss the challenges identified by the wind companies, including their skepticism of the key legislation enacted by the government to encourage a buildout of renewable energies.

4. Key challenges

4.1. Supporting legislation

As of 2012, the main laws undergirding the legislative framework for the Energiewende include the aforementioned Renewable Energy Act (referred to by its German acronym, EEG, for the remainder of the article), the Renewable Energy Heat Act (Erneuerbare Energien Wärmegesetz), the Grid Expansion Acceleration Act (Netzausbaubeschleunigungsgesetz) and the Energy Economy Law (Energiewirtschaftsgesetz). When asked whether they believe these pieces of legislation are sufficient to achieve the Energiewende by 2050, not one company gave an affirmative answer. On a scale from “not at all sufficient”, “hardly sufficient”, “partly sufficient/insufficient”, “seemingly sufficient” to “fully sufficient”, two companies selected the ambivalent middle answer and three gave the more negative answer of “hardly sufficient”.

Despite the negative reaction to the core pieces of legislation, a few of the companies responded slightly more positively towards specific legislative features, such as the FITs provided by the German government to encourage investment in renewable energies by compensating for higher generation costs. Although generation costs have steadily decreased, due to technological innovations and higher capacities, renewable electricity is usually still more expensive than that sourced from conventional fuels. FITs thus comprise a core element of the investment calculus for renewable energies.

For onshore wind, the EEG provides an initial FIT of €0.0893/kW h for the first 5 years, a time-independent tariff of €0.0487/kW h, and an optional bonus of €0.0048/kW h if the turbine is in operation before January 1, 2015. When asked to select how well these FITs make new onshore turbines in new locations competitive to other forms of electricity generation (ranging from “not at all sufficient” to “completely sufficient”), the wind companies provided a broad mix of answers. Two of them judged the incentives as “hardly sufficient”; one opted for the ambivalent answer of “partly

sufficient/insufficient"; and the more positive "seemingly sufficient", and "completely sufficient" were selected by one company each. One could argue that these firms have a vested interest in higher FITs (the higher the FIT, the more they can charge for turbines and farms), which makes the positive answers quite interesting. Also, the answers appear to be unrelated to the respondent's market share. One of the two largest firms in the survey found the FITs "completely sufficient"; the other large company answered "hardly sufficient".

The legislation supporting the Energiewende will most likely be updated within the next few years, but not before the federal elections in Fall 2013 (Ali-Oettinger, 2013). Not all changes under discussion, however, are intended to hasten the deployment of renewable energies but rather to moderate the tempo and thus the costs. In recent years, renewable energy capacity has increased at a greater than expected rate, which has consequently caused greater than expected increases in electricity costs and reallocation charges. Presently, the additional costs for renewable electricity are passed along in the electricity price to end consumers as a surcharge. This annually adjusted reallocation charge has continually risen over the past decade (Pfaffenberger and Chrischilles, 2013). Enthusiastically embracing the Energiewende, the individual German states have set highly ambitious state-level goals for renewable energies, which, when added together, exceed the federal government's goals, raising concerns about future costs.

To keep costs down, the Federal Ministry of Economy and Technology (BMWi) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), under the relatively conservative Altmaier, have proposed a fundamental revision of the main law, the EEG, including the surcharges for renewable electricity. One proposal is that the federal government (namely, the BMU and the BMWi) and the states should determine whether additional restrictions on the capacity expansion of renewable energies, especially for the wind and biomass sectors, are necessary. At the moment, however, the German government pushes wind and solar energy buildout with FITs on the one hand while strictly controlling expansion and environmental impacts on the other. For the most part, our respondents found the restrictions on wind energy troubling.

4.2. Onshore restrictions

The high development potential for wind energy identified by our survey participants can only be achieved if sufficient turbines are erected in appropriate locations. Over the past two decades, onshore wind has rapidly expanded and Germany now has about 23,000 turbines, 796 of which were constructed in 2012 (Fraunhofer Institut für Windenergie und Energiesystemtechnik, 2013). As a result of onshore wind buildout, many of the prime locations have already been tapped. For example, most land regions along the windy coasts of the North and Baltic Seas are already developed for wind, leaving only limited possibilities for the construction of new turbines. The next

best areas offer less than optimal conditions, and it is debatable to which extent technological innovations – which could increase the output of even less favorable sites – can enhance the attractiveness of these locations (Wallasch et al., 2011). A recent study by the Federal Environment Agency (Germany's environmental authority, which is assigned to the BMU) assessed that about 10 percent of Germany's land surface is suitable for wind turbines—an area and potential much greater than previously estimated (Umweltbundesamt, 2013). However, even when new locations are found, their exploitation may be hindered by other factors.

First, the wind industry in Germany, as in other countries, must contend with public opposition to wind turbines and protests. This resistance – often referred to as a NIMBY ("not in my back yard") response – can be caused by myriad reasons, ranging from health concerns to property value impact to aesthetic objections. We asked our respondents to judge how problematic citizen protests might be in delaying or derailing the buildout of onshore wind energy projects. Given a choice of seven answers, ranging from 1 ("not very problematic") to 7 ("very problematic"), two of the companies selected 6, two selected 5 and the fifth opted for the middle value of 4. These results indicate that, for the most part, the wind companies found potential citizen protests problematic. Germany is not alone in confronting the NIMBY dilemma presented by renewable energies. In early 2013 in the United Kingdom (UK), for example, a Minister warned that the drive for greater wind turbine deployment "should not be used as an 'excuse' to impose the eyesores in the countryside" (Boles, 2013).

Germany has implemented strict regulations regarding the location and height of turbines in order to minimize disturbances to people living near wind farms, such as shadow flickering and acoustic emissions. When asked to rate the impact of these regulations on Germany's ability to achieve its Energiewende goals, using a 7 point scale ranging from 1 ("very restrictive") to 7 ("not at all restrictive"), the answers tended towards seeing the regulations as inhibitive. Three of the five firms selected the

[page 1485]

value of 3, meaning they judged the regulations as somewhat restricting goal attainment. One company opted for the neutral value of 4 and the largest company in our sample indicated, by selecting the 6, that the regulations were not very restrictive.

The challenge posed by finding optimal locations also surfaced in response to a separate question which asked respondents to select from a list the most significant hindering factors for onshore wind expansion. The options included financing, transportation and logistical issues associated with construction, delayed grid integration, technical problems, operating costs, time to produce wind turbines, lack of qualified workers, the availability of locations for new wind turbines, and "fill-in-the-blank": tied for second place in the results were the availability of locations and construction challenges. One company additionally volunteered that the approval

processes for new wind turbines were especially obstructive. However, the number one impediment identified by our companies was Germany's lagging grid expansion.

4.3. Grid expansion

Our survey revealed a strong and clear consensus that insufficient grid expansion is considered *the* major threat to the buildout of renewable energies in Germany: four companies ranked it as the top obstacle and the fifth company placed it second. The problem is not just expanding the grid, but modernizing it.

One challenge is the bi-directional integration of electricity from small and local renewable energy sources such as that from household photovoltaic panels. Excesses from these sources should be absorbed into the system, but when they fall short, consumers need to be supplied from the grid. This degree of sensitivity will require modernization – specifically, smart grids and smart meters to synchronize supply and demand – and decentralization. At the moment, however, the majority of Germany's gross electricity, more than 70 percent in 2011, is produced centrally at large power plants. Scenarios from the BMU foresee reducing this level of aggregation by some 50 percent by 2050 (Wallasch et al., 2011).

New high-voltage transmission lines will also be needed to transport electricity from windy, energy-producing northern Germany to energy-intensive western and southern Germany. The German Energy Agency, which goes by the acronym *dena*, has published several major reports on grid expansion. In its 2012 report, dena presented various scenarios of how Germany could meet over 60 percent of its electricity consumption with renewable energies by 2030. The least expensive scenario would require 11,200 km of new high and extra-high-voltage lines and cost €11.1 billion (including the costs of connecting offshore wind farms). Fulfillment of this base scenario would require an average of at least 600 km of new lines to be built each year between 2013 and 2030 (dena, 2012). In 2012, the four German transmission system operators, TenneT, 50Hertz, Amprion, and TransnetBW, published their vision for a network development plan, which approximated dena's proposal (Netzwerkentwicklungsplan Strom, 2012).

Similar to the viewpoint of the wind companies in this survey, the BMWi has stated that “the expansion of the electricity grids is the most important prerequisite to ensuring the greater penetration of renewable energy in electricity production” (BMWi, 2012 p. 16). This expansion, however, faces several significant challenges. Speed has thus far not been a hallmark of Germany's grid expansion. In 2005 dena issued its first study calling for 850 km of new lines to be built by 2015. As of 2010, only 90 km of these lines had been built—an average of less than 20 km per year (dena, 2010). When we asked the wind companies if they thought the amount of time the transmission system operators require to expand the grid was appropriate (on a scale from “not at all appropriate” to “completely appropriate”), four out of five respondents gave the most

negative answer, “not at all appropriate”, and the fifth gave the second most negative answer of “hardly appropriate”.

Even when the hurdles delineated above are surmounted and the decision has been made to go forward with new line construction, other problems may arise. Similar to wind turbines, electricity infrastructure often elicits a NIMBY response. As recognized over 20 years ago by one of the classic studies on public opposition, many people react negatively to electricity lines and substations in their neighborhoods (Furby et al., 1988). In Germany, for example, more than 12,000 citizen objections were filed against one of the planned major transmission corridors to connect northern and southern Germany (Fischedick, 2012).

When asked about the biggest challenges facing onshore wind energy, four of the five companies cited delayed grid integration. However, with regard to offshore wind energy, the five companies were united in their opinion that delayed grid integration was the most serious problem. In Germany's Energiewende plans, offshore wind is intended to play a significant role; but, as discussed earlier, our wind companies were not confident of the development potential for offshore wind. In the next section we explore the unique challenges confronting the German offshore wind industry.

4.4. Offshore wind

By the end of 2012, only 68 offshore wind turbines with grid connection had been erected in German waters. These turbines made up a miniscule 5 percent of the overall European offshore industry, which at the time comprised more than 2000 turbines with a capacity of 5900 MW fully connected to transmission infrastructure. To provide an even more direct contrast: at the end of 2012, 68 turbines generated electricity to the German shore, with a combined total capacity of 280 MW, whereas in 2012 alone the UK erected 450 offshore turbines with a capacity of 1650 MW (Fraunhofer Institut für Windenergie und Energiesystemtechnik, 2013). This difference cannot be attributed to the companies' expertise, as many of the major players in Germany are actively involved in the UK's offshore wind farms, including Siemens, REpower, Vestas and Bard Holding.

To achieve the Energiewende goals the German government would like to see offshore capacity reach 10,000 MW by 2020. The number of turbines this would require depends on the capacity of each turbine, but some quick calculations indicate the scale of deployment that would be required: 10,000 MW could be produced with either 2000 turbines generating 5 MW each, 1428 turbines generating 7 MW each, or 1000 turbines generating 10 MW each (the latter is still in the research and development stage). These figures mean that to attain 10,000 MW by 2020, over the next 7 years Germany would have to erect roughly 1950 new 5 MW turbines (278 per year) or 1400 new 7 MW turbines (200 per year).

Considering that by end of 2012, Germany had constructed a total of only 68 turbines – and a few more not yet connected to the grid – Germany's offshore wind industry would have to sharply accelerate construction. However, the German offshore wind industry faces several thorny and somewhat interrelated problems.

First, to protect tourism, nature conservation areas, shipping lanes and fishing grounds, Germany requires that turbines be placed farther offshore than other countries do, such as the UK or Denmark. In general, German turbines are located around 40 km from the coastline, which is 17 km further than the European average. Consequently, they must be built in deeper waters: around 30 m compared to 23 m for the average European wind farm (Wilkes et al., 2012). A further exacerbating factor is weather: it worsens the farther out to sea. The combination of greater distances to shore, deeper waters and rougher weather limits the construction period to between May and September, rendering offshore projects more complex and costly. It comes as no surprise that the wind companies in our survey felt that, after delayed grid

[page 1486]

integration, the next greatest challenges were the technical, transportation and logistical issues associated with offshore construction.

Because of the more costly nature of constructing offshore wind turbines, the second major issue delaying the buildout of the German offshore industry is financing uncertainty. For at least two reasons, banks have been reluctant to finance offshore projects. First, German offshore wind farms do not offer an attractive rate of return. The consulting and accounting firm KPMG has estimated the average project return of a model German wind park at 7.1 percent, which it considers too low to adequately cover the associated risks (Köppe et al., 2010).
Second, the offshore industry is caught in a quandary: Banks are unwilling to provide financing to offshore wind farms unless a grid connection exists, but are also reluctant to finance the grid connections without certainty of a wind farm at the other end. German transmission system operators are required to supply infrastructure, but if onshore connections are plagued by delays and uncertainties, these problems are even trickier for offshore. For example, the wind companies in our survey felt that the North Sea offered greater development potential than the Baltic Sea; however, the German North Sea coast is home to the Waddensee, an area under environmental protection. Transmission cables can be laid, but only during certain times of the year and in specific corridors.

In the spring of 2012, the complexities surrounding the offshore wind industry received national attention when RWE, the leading European power producer, announced significant delays in the construction of the 288 MW offshore wind farm Nordsee-Ost (Spiegel Online, 2012a). Half a year later the second largest utility company, EnBW, stated it was indefinitely pausing construction of “Hohe See”, a North

Sea 500 MW, €1.5 billion offshore project (Spiegel Online, 2012b). In the media maelstrom that accompanied these announcements, journalists, research institutes and the wind industry publically voiced their doubts about the feasibility of the medium and long-term goals for Germany's offshore wind industry. As the German Minister of Transport, Peter Ramsauer, opined to Wallstreet:online (2012), it is the onshore and not the offshore wind industry that will contribute the most economical expansion potential in the short and medium term. Electricity generated by offshore wind farms should ultimately help alleviate Germany's reliance on nuclear and fossil fuel power, but Germany will only achieve its offshore goals if the government implements significant changes.

To overcome the grid conundrum and the challenges ensuing from the myriad restrictions, the German government has pursued a two-pronged approach, offering both compensation for grid delays and greater construction incentives. Additional 2012 amendments to the EEG ensure developers that financial losses accruing from delayed grid connections will be compensated even if the wind farm is not yet feeding electricity into the grid. This not only increases costs to end consumers in the form of additional charges on their electricity bills, it also means they are paying for electricity that is produced but not provided. On the incentive side, offshore developers have a choice between a payback period of 12 years with FITs of €0.15/kW h or, as implemented in the 2012 amendments, a shorter timeframe of 8 years with FITs of €0.19/kW h. In both cases, companies would get a “sprinter” bonus for turbines erected before January 1, 2016 (in December 2012, this deadline was extended by 2 years).

When we asked survey participants if they thought the government's offering of two different timeframes and payoff structures was on the right track (a five-point scale from “completely correct” to “completely wrong”), only four companies chose to answer and they diverged entirely. None of the companies found it completely wrong and the other four options were selected by one company each. In other words, there were more positive than negative responses, but no strong consensus emerged.

Whether these changes and the 2012 legislative reforms will provide a sufficient boost to the offshore industry remains to be seen. At the moment, preparatory work has begun on several offshore wind farms while proposals for other projects, with a capacity of 9050 MW, have been approved. The government is relying on funding the offshore incentives and compensation program through yet another additional surcharge to the electricity price paid by German consumers. Considering that policy makers and the media have recently focused on the costs of the Energiewende, it is not clear if these surcharges can be maintained, which could mean that the incentives they support will be either reduced or dropped.

5. Discussion and implications

In 2010 the German government set far-reaching and ambitious goals for renewable energies to supplant fossil fuels in its electricity mix. After the Fukushima disaster in March 2011, the German government abruptly decided also to phase out nuclear power while keeping its original Energiewende goals. The Energiewende has dominated the German political arena and is an almost daily topic in the German news (and frequently mentioned in international media), but the voice of Germany's renewable energy industries has been noticeably absent. In this article, we report the opinions of five of Germany's top wind turbine manufacturers and project developers. Together, these five firms represent the lion's share of the German wind market. Although these five companies – and the German wind industry in general – represent only one small set of actors in the Energiewende, they are highly knowledgeable about Germany's energy landscape and of the promise and limitations of the wind industry in particular. Their perspective, we felt, should be reported.

5.1. Common opinions

Although some questions elicited disparate responses, our results showed convergence of opinion on many key issues, allowing us to draw a composite perspective. In summary, there was weak consensus that the overall goals for renewable energies are realistic, with only one company notably pessimistic. The companies were more united in their optimism regarding the goals for onshore wind, but most were doubtful about the offshore goals. Two of the companies reacted positively to the legislated incentives to encourage onshore investment, but not one of the companies thought the main pieces of legislation, in general, were sufficient to actually achieve the renewable energy goals. This alignment of opinion was also evident when it came to many of the impediments facing their industry and we surmise the two are related: the companies' skepticism over the core legislation is tied to their doubts over its efficacy to address the main challenges.

Almost all of the companies saw grid expansion (or lack thereof) as the upmost serious obstacle to both onshore and offshore development and considered transmission system operators too slow to act. They identified finding new locations as the second most significant problem facing onshore wind development. For the barriers to offshore wind, two items shared second place: technical and transportation/logistical problems.

5.2. Push–pullback contradictions

In addition to providing a composite picture of the majority of Germany's largest wind companies, this study also exposed certain

contradictions within the German government's approach to energy. As seen from the perspective of the wind companies, the government – rather than offering a

comprehensive and clear way forward – seems to be sending an array of conflicting push–pullback signals. For example, incentives are provided to create new wind farms and repower old ones, but these projects are subject to tight constraints, both onshore and offshore. Also, the government has set high offshore goals and requires that transmission infrastructure be supplied to offshore wind farms, but has not managed to impel either the transmission system operators or the banks that underwrite such infrastructure projects to move more quickly.

Germany does not have a designated ministry for energy issues, so competencies are spread across several departments and institutions. The two ministries that have taken the lead, the BMWi and the BMU, seem to have occasionally engaged in a tug of war, but with the May 2012 appointment of Peter Altmaier, the BMU is becoming more aligned with the traditionally conservative BMWi: both are now concerned with costs.

The electricity prices consumers see on their bills are a composite, comprising the wholesale market price plus numerous additional charges, such as the network and EEG subsidy surcharges and taxes. Electricity consumers in Germany are divided into pricing categories, for example, industry or private households; and, during the past 6 years, prices for some categories rose almost 40 percent (Pfaffenberger and Chrischilles, 2013) even though wholesale prices decreased. The increase is due to the additional charges, such as those to encourage renewable energy buildout and to support network maintenance and expansion. Many consumers and policy makers have reacted with alarm to the very visible electricity price increases—even though electricity prices have not risen as high as fossil fuel prices.

Since his appointment in May 2012, Altmaier has started open discussions about the time-table, scope and costs of the Energiewende. In his agenda, the stability of electricity prices should take precedence over the Energiewende goals (Illner, 2012) and in early 2013 he proposed to “brake” prices by limiting renewable energy subsidies and thus the surcharges on electricity bills—a measure that was rejected (Untersteller, 2012 and Ali-Oettinger, 2013).

If the individual states proceed with their plans to deploy renewable energies, the combined increase in renewables would far outstrip the federal government's goals, which has heightened the federal government's concerns over prices. Here an additional push–pullback dynamic has unfolded: Whereas the federal government had pushed states to embrace renewable energies, now, fearing an overproduction of renewable energies and skyrocketing prices, it is attempting to correct the course by setting caps on wind and biomass capacity (Spiegel Online, 2012c). At this point in time, it is unclear what the implications are for offshore wind capacity: How can the government simultaneously promote offshore wind while reining in the onshore wind plans of the individual states? What is clear is the emerging struggle over energy governance. During an energy summit of federal and state officials in late 2012, state-level leaders rejected

Altmaier's efforts to pull back their planned increases in renewable energy capacity, leading Altmaier to threaten to “identify by name during the upcoming elections those who are guilty of not agreeing to a national consensus on energy” (Dapd, 2012). Just as Altmaier's heavy hand in the negotiations carries risks, so do the government's stop–go oscillations. Either too heavy a push or too strong a pullback could endanger the Energiewende.

In the drive to encourage renewable energies and energy conservation, two of the greatest challenges are the cost differences between conventional and renewable energy sources and the related issue of creating a market design suitable for electricity markets dominated by renewable energies. At the moment, renewable energies are typically more expensive to produce, which is partly due to technology costs and to historical developments that advantage conventional energies: many associated costs of conventional fuels are still externalized (Fischedick et al., 2011). Under current pricing mechanisms, one of the risks of too heavy a push – too speedy a transition – is abruptly more expensive electricity. However, once the costs of different energy sources are “levelized”, renewable energies, which have little to no fuel costs, can outperform conventional energies (Kost et al., 2012). In occasional areas with high and constant wind speeds, onshore wind power already is cost-competitive with conventional forms of energy (Channell et al., 2012).

Renewable energies thus exert diametric influences on price: The cost of encouraging renewables raises prices, but the lack of fuel costs reduces them. The balance between these upward and downward pressures will change over time to the advantage of renewable energies, as enticements become less necessary and the low-fuel benefits prevail.

The fact that renewable energies have negligible marginal costs (which are traditionally associated with fuel costs) contributes greatly to the second challenge: market design. A price architecture needs to be constructed that is appropriate for renewable energies, sufficiently sensitive to respond to smart infrastructure, and allows investors to recover their costs in back-up capacity projects—the energy plants running on conventional fuels that are needed when, for example, the wind does not blow or the sun does not shine (see Friedman, 2011 and Winkler and Altman, 2012). At the moment, no definitive solutions obtain for how to reshape the market. Under the current market design, a significant buildout of renewable energies creates longer-term disincentives to investment in conventional energy plants and causes, in the short-term, significant price increases for end consumers.

Until a more comprehensive market solution emerges, some German policy-makers are tending toward the simple but brute method mentioned above to halt the immediate problem of escalating electricity prices: reduce the costs of renewable energies by reducing the pace of renewable energy deployment. However, just as strong push signals carry risks, so do overly heavy pullback signals. Too great a reduction in

incentives hazards stalling the Energiewende, which would give rise to other problematic costs, even if they do not appear in electricity bills. For example, if Germany falters in its support of renewable energies, it jeopardizes its position as the global leader in wind energy technologies. Rather than ask our respondents for their opinions on potential industry impacts should the Energiewende lag, in late 2012 we interviewed several renewable energy experts – employed by a consulting firm and not by the wind industry – for their insights.

On a practical level, these experts believed that if the German government hesitates, then the wind industry might look to more lucrative and quickly expanding markets. One expert drew a parallel to Germany's earlier leadership in battery technology: when Germany cut support, its battery industry migrated to Asia. One consequence thereof is the world leaders in hybrid and electric vehicles are located in the East—and not in Stuttgart, Munich, or Wolfsburg, Germany. Fewer wind turbines and photovoltaic modules also mean fewer jobs. A recent study found that, per Terawatt hour of electricity produced, wind and photovoltaic energy employs between 400 and 410 people, whereas for gas and coal plants it is only 80 to 125 people (Gabriel, 2012). Some German energy experts have raised concerns that a failure to adequately support the Energiewende will result in a return to conventional energies (Röhrkasten and Westphal, 2012).

This discussion should not imply that German policy makers are seeking to stop the Energiewende but does highlight the risks of their current push–pullback approach. On a more positive note, around the same time the federal government was seeking to limit the growth of renewable energies, it was also passing measures to speed grid expansion, which our wind companies identified as the

[page 1488]

most serious problem confronting a renewable energy buildout. In mid-December 2012, the German government approved construction of three high voltage corridors (2800 km in total) from northern Germany southwards. To reduce the permitting and construction time from the current average of 10 years to 4 years – and to limit the ability of protestors to prolong the process – the German states will allow permitting at the federal level. To mitigate public resistance, lines near heavily populated areas will be built underground (Reuters Deutschland, 2012).
According to the companies in our study, the goals for renewable energies set by the German government are for the most part attainable; the weak points are the contradictory signals and legislation. As the German Energiewende is an unprecedented initiative to transform the energy mix and consumer behavior of a heavily industrialized country, it is understandable that policy makers seem to be “learning by doing”: they are pioneers in a new land and thus have no models to follow of how similar countries have accomplished such transitions.

What could other potential energy transition countries learn from Germany? Although German policy makers have derailed neither the Energiewende nor the economy with their contradictory push–pullback approach, it would seem advisable for other countries to try to avoid sending mixed signals; for example, by initiating a transition with an appropriate market design and with greater coordination from the outset, such as between various levels of government (federal and state) and between the main actors (such as transmission system operators and electricity retailers). On a positive note, as the Energiewende does appear to be underway, the most important message Germany conveys is that a transition is indeed possible.

Acknowledgements

For their help – whether with creating the survey, reviewing preliminary drafts, or supplying data or advice – the authors wish to thank Marc Frey, Klaus Boehnke, Manfred Fischedick, Wolfgang Pfaffenberger, Nele Friedrichsen, Julia Kusznir, Jürgen Gabriel, Marius Buchmann, Christine Brandstätt and Roland Meyer. We also express our gratitude to our interviewees, from both the wind and consulting sectors, and to the anonymous reviewers of this article.