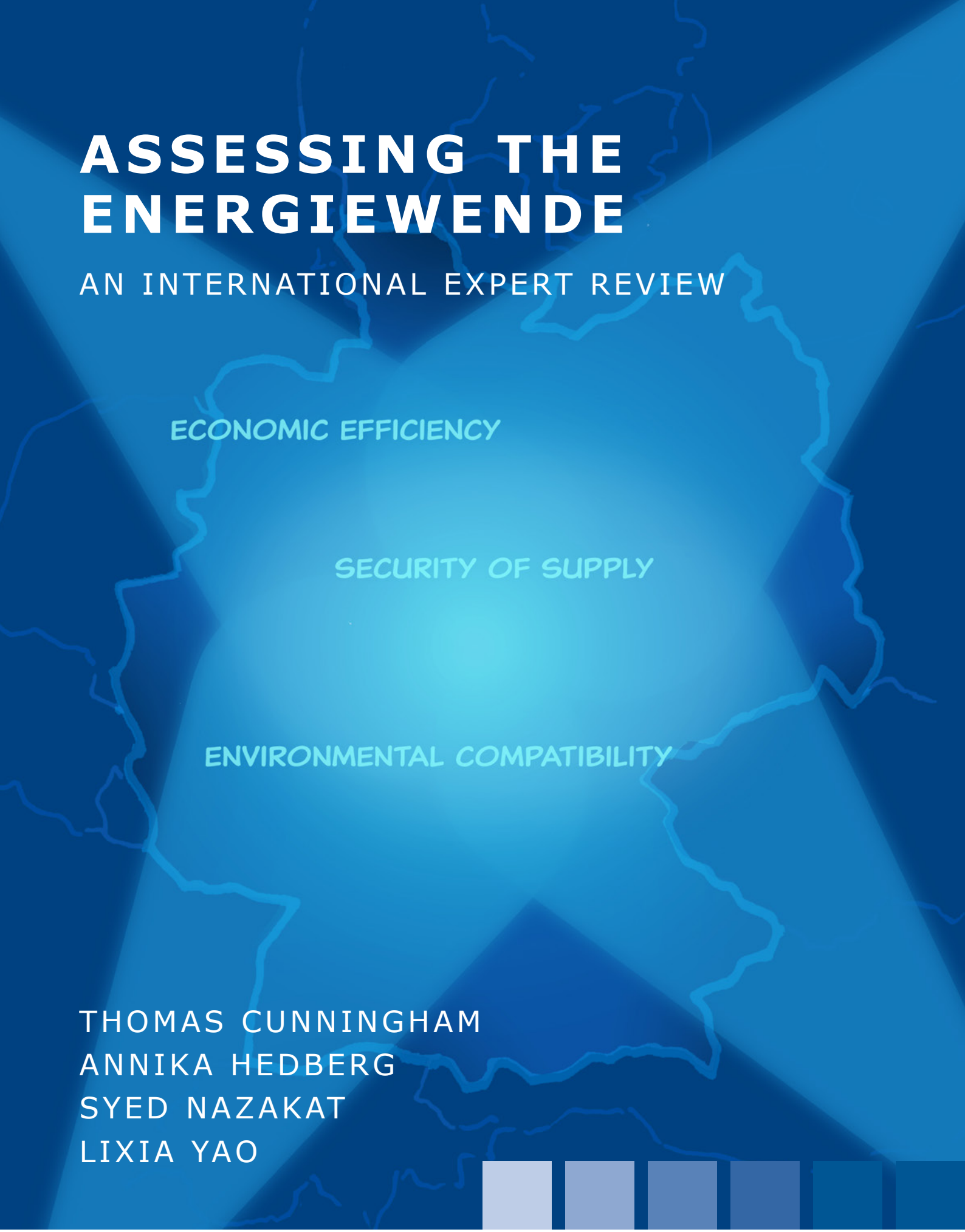
ASSESSING THE ENERGIEWENDE

AN INTERNATIONAL EXPERT REVIEW



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KEY POINTS

- The rapid expansion of renewable energies in the area of electricity can be seen as a partial success of the *Energiewende* so far, but at a very high cost through high electricity prices.
- The urgently needed expansion and conversion of the power grid continues to be too slow and must be accelerated through appropriate legislation.
- The European context of the *Energiewende*, in view of its central importance, must be given much more attention in the future.
- From an international perspective, the *Energiewende* is not yet perceived as a model for other countries, but does offer valuable experience and knowledge.
- If its further implementation is successful, the *Energiewende* could be inspirational to other countries and become a model for success.

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FOREWORD

JASPER EITZE

"It is a Herculean task […]. To achieve all that we have set ourselves to do will be tantamount to squaring the circle"[1], said the German Chancellor Dr. Angela Merkel in June 2011. The occasion was the decision, following the Fukushima nuclear accident in Japan, to shut down all nuclear power plants in Germany by the end of 2022 at the latest. But the nuclear power phase out represents just one element of an energy transition which aims to completely overhaul the energy system of the world's fourth largest economy.

In view of such an enormous political challenge, every German federal government must ask itself at the beginning of each new legislative period the following questions: Where do we stand with the *Energiewende* (energy transition)? How can we reconcile its long-term goal with the need to ensure a reliable, cost-effective and resource-saving energy supply in the short to medium term so that Germany's economic competitiveness remains on track and public support is maintained? Against this backdrop, since 2012, a monitoring report has been published annually on behalf of the Federal Government, and a progress report on the *Energiewende* is published every three years by a national panel of experts.[2]

But how do international experts view the *Energiewende*? Such perspectives appear to be all the more important because Germany's energy transition has been linked to its aspiration of playing a leading role throughout Europe and the world – in political, economic, ecological and social terms as well as from technological, geo-strategic and security policy points of view.

This publication presents the views of four international energy experts. Their articles analyse and evaluate the progress made by the *Energiewende* so far and make recommendations for future policy decisions. The authors thus provide points for furthering the progress of the German energy transition into a sustainable model of success, with positive impacts within Europe and worldwide.

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ENERGIEWENDE: FROM GERMANY'S PAST TO EUROPE'S FUTURE?*

THOMAS CUNNINGHAM**

A harmonized energy, environment, and labor policy that could only come from within Germany, but which must spread beyond Germany to truly succeed.

THE FASCINATION WITH THE *ENERGIEWENDE*

Germany's energy policies have long been a source of fascination in the United States. US experts follow the twists and turns of Germany's power sector; they marvel at how Germany's energy policies are striking in their level of ambition. Even more remarkable to outsiders is how those policies have proven resilient despite several challenges that would typically lead to failure in other markets: high costs to consumers, major strains on influential utility companies, and negative impacts on competitiveness in a global economy. Germany's energy transition, or *Energiewende*, is indeed unique. Although it is difficult to compare to the situation in the United States, which does not have a unifying energy policy at the federal level, US observers can learn much from the German experience: despite the uncertainties, risks, and costs, the German public remains staunchly supportive of the *Energiewende* – arguably because it brings energy, environment, and labor policies together. But for the *Energiewende* to ultimately be successful and durable, Germany must expand the lessons it has learned to the European level, and apply that ambition to achieve environmental sustainability, economic competitiveness, and energy security to the entire European Union (EU).

A GERMAN APPROACH TO ENERGY WITH DEEP HISTORICAL ROOTS

Before renewables proliferated and wholesale electricity prices plummeted in Germany, before the Fukushima Daiichi nuclear disaster in Japan, and before addressing climate change became a global policy imperative, Germany was committed to using clean energy to improve energy security, environmental sustainability, and industrial competitiveness. Indeed, one needs a historical lens to understand the *Energiewende* that Germany is making today. The story of Germany's energy path from the 1970s to the present helps illustrate the country's roadmap to a carbon- and nuclear-free future.[1]

The strong environmental ethos of today's Germany emerged from student-driven social and antiwar movements in West Germany during the Cold War. Fear of nuclear war and concerns about energy security during the oil crises of the 1970s, compounded by the 1986 nuclear crisis at Chernobyl galvanized opposition to nuclear power and helped link environmental concerns with those about energy choices and create a mindset of sustainability.

Germany still is the world's biggest lignite-producer.

Alongside the anti-nuclear momentum, questions arose about the long-term viability of coal as an economic engine for West Germany, as did social and environmental concerns about lignite production. Germany remains the world's largest producer of lignite,[2] although that distinction has come with social costs on the production side as well as environmental costs on the consumption side; maintaining production has required razing towns to access the resource in parts of Germany.[3] These experiences help explain the consistency behind the country's bold carbon emissions reduction targets.

Meanwhile, Germany's economy has been driven by its unique manufacturing sector, known as the *Mittelstand*, which is comprised of small businesses that make small sets of highly specialized products used in other products manufactured around the world. This sector, which constituted nearly 80 percent of Germany's jobs in 2011 and helps explain Germany's incredible economic power and resilience, is itself explained not just by a highly effective labor training culture in Germany,[4] but also by reliable energy supplies, much of which must be imported due to a lack of domestic natural resources. Part of this energy has come in the form of natural gas, both produced in Europe and imported from the Soviet Union. The rest has come from nuclear power and coal. But with public opinion shifting away from nuclear power, policies emerged in the 1990s to produce sustainable energy that could serve the energy demands of the *Mittelstand* – while also making the energy sector a customer of *Mittelstand* businesses, which would manufacture the sector's clean energy products.

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For observers in the US, it is important to note that this historical experience also informs Germany's current views on energy security vis-à-vis Russia. German energy ties to Russia, now so problematic in the context of developments in Ukraine, were an essential part of West Germany's Cold War policy of Eastern engagement, or Ostpolitik. This approach prioritized building economic linkages to the Soviet Union in the hopes that mutual dependence would prevent further political alienation between Moscow and the West.[5] And even in the darkest days of the Cold War, the Soviet Union never interfered with Germany's energy supply. Because of these ties, Germany has never felt the energy security threat that its neighbors in Eastern Europe have faced.

IMPLEMENTATION EXCEEDS EXPECTATIONS, AND HOUSEHOLDS WILLINGLY BEAR THE COSTS

At the time of unification, Germany chose the feed-in tariff (FIT) as the policy mechanism to accelerate the deployment of wind and solar generation. The FIT provided guaranteed rates of return for suppliers of renewable energy that would otherwise be highly unprofitable. A renewable energy law passed in 2000 (the *Erneuerbare-Energien-Gesetz* or EEG), established an FIT tariff scheme guaranteeing absolute rates of return for twenty years for renewable producers. The law exceeded all expectations: the share of renewables in the energy mix grew from around six percent in 2000 to 31.5 percent in 2015.[6] (In the United States, which provided federal support to renewables in the form of production tax credits, the share of renewables in energy consumption grew much more slowly, from nine percent to just ten percent in the same timeframe.)[7]

The EEG from the year 2000 was both a blessing and a curse.

But the blessing was also a curse: the EEG had no mechanism to adjust the tariff to market demands. It quickly became clear that the tariff was set too high, so that the unexpected level of deployment brought unprecedented costs which were paid by ratepayers as a surcharge on their electricity bills. Energy-intensive industries were exempt to maintain their international competitiveness, so the costs fell mainly on households. The surcharge amounted to 22 percent of the average household bill, helping account for electricity costs that are nearly double what households pay in the United States.[8]

Although there was an outcry about the burden the EEG posed to consumers, the law was not overturned because extraordinary energy efficiency in German households offset the higher electricity costs.[9] Although electricity prices are higher on a kilowatt-per-hour basis in Germany than in the United States, German households are three times more energy efficient than their US counterparts. The efficiency gains continue to increase. As *Clean Energy Wire* reported in late 2016, "Over 20 years, German households reduced their power usage by ten percent, while consumption in the United States increased by 20 percent."[10]

UTILITIES UNDER STRAIN; NUCLEAR PHASE-OUT ACCELERATES

Even as it pushed retail prices up, the EEG pulled wholesale prices for electricity down, straining traditional utilities by depriving them of revenues. The FIT guaranteed that renewables had "dispatch priority", meaning that grid operators had to use renewable energy at every opportunity regardless of cost or convenience. Moreover, two months after the March 2011 Fukushima disaster hit Japan, nine of the seventeen nuclear plants still operating in Germany were shuttered for safety reasons. Chancellor Merkel seized the political momentum to mandate a complete shutdown of nuclear power by 2022. Nuclear as a share of the electricity generation mix fell from around 25 percent to 16 percent that year, further weakening utilities' revenue stream.[11]

Coupled with the continued deployment of renewables (31.5 percent of the gross electricity consumption in 2016[12]) wholesale electricity prices collapsed, and with them, so did the profitability of utilities. Major power companies E.ON and RWE split their companies to separate profitable renewables and electricity services from toxic nuclear and fossil generation assets and sued the government to recover some of the losses from those stranded assets.[13] Discussion about how to maintain fossil fuel generation capacity – necessary to manage peak demand and baseload but cost-prohibitive in the unfavorable policy environment – included the creation of funding schemes for utilities to maintain baseload and peaking capabilities on a standby basis known as capacity market. This ignited a new policy debate at the EU-level about whether utilities should be subsidized for their polluting assets as well as their clean ones, and if such aid was an unfair distortion in the European common market.[14]

INTERNATIONAL IMPACTS AND PERVERSE POLICY OUTCOMES

In Germany, with its energy-intensive *Mittelstand* manufacturing base, maintaining competitiveness in a globalized economy is critical. Although the exemption from the renewable energy surcharge enjoyed by energy-intensive industries was intended to preserve that competitiveness, in 2013 the European Commission announced an investigation to determine if that exemption placed those companies at an unfair advantage over European competitors.[15]

Meanwhile, the shale revolution in the United States reduced costs dramatically for energy-intensive industries located there. Some German companies like BASF shifted production to the

United States as a result.[16] With the EU's emissions trading scheme (ETS) largely ineffective as a price signal, the most carbon-intensive fuels like coal and lignite remained the lowest-cost options for power generation.[17] Gas was squeezed out of the power mix in Germany; new gas-fired plants were mothballed and the lifespans of old, dirty coal plants were extended.[18] In the United States, coal consumption decreased in the face of abundant cheap gas, but exports continued, including to Germany.[19] In 2015, year-on-year emissions in Germany actually increased, but fell again in 2016.[20] Perversely, Germany's policy on renewables led to increased emissions, while US emissions declined amid an energy boom.

Even as the profit model for utilities changed irrevocably in Germany, changes within the grid increased demand for their services. To deal with demand surges and periods of low wind and solar production, coal plants that were designed to run at constant rates were used to provide peak power by ramping up and down on short notice, shortening their lifespans.[21] The German power grid also lacked the transmission infrastructure to bring the wind power produced in northern Germany to the industrial consumers in the south. As a result, electricity was pushed into neighboring countries, particularly Poland, the Czech Republic, and the Netherlands, obliging the power grids in those countries to adjust to the influx of power, straining political ties as well as electrical interconnections.[22]

Ironically, the German policy on renewable energies led to increased emissions.

The aggressive installation of renewables in Germany and other European countries like Spain created massive demand for manufacturing. Electricity consumers and investors in those countries effectively subsidized the fledgling renewables industry – those initial investments in wind and solar, in addition to technological improvements and manufacturing advances, helped them achieve the commercial viability they enjoy today. But German manufacturers did not reap all the benefits of this new demand. By 2010, China manufactured over half of the world's solar panels,[23] helping bring the cost of solar down but also undercutting the potential for Germany's *Mittelstand* to provide the core manufacturing base for its renewables sector.

THE OUTLOOK TODAY

Recent reforms to the EEG have replaced the automatic FIT with an auction system for utility-scale projects, so that only a predetermined amount of new renewables capacity will qualify for the most favorable incentives, and the FIT for rooftop solar is vastly lower than it used to be.[24] The future of the utilities is more stable thanks to a July 2016 policy establishing a "strategic reserve" to ensure sufficient electricity generation capacity for at least four years, by which time renewables deployment is expected to obviate the need for reserve generation capacity.[25]

As a result, the *Energiewende* today is on better footing as a viable approach to advance renewable energy deployment without endangering economic competitiveness in Germany – in effect, it has become a viable labor policy. The *Mittelstand* has benefitted: although the EEG was criticized for increasing costs to German small business,[26] by 2008, more workers in Germany were employed in renewable energy jobs than in conventional energy.[27] Furthermore, by declaring in 2014 that the exemption from the EEG surcharge enjoyed by energy-intensive industries did not violate EU rules, the European Commission effectively sanctioned the German approach to preserving industrial competitiveness by shielding that sector from the costs of renewable energy.[28]

The European Commission investigated the legality of the "strategic reserve," which gives support to German utilities that competing electricity providers in other EU countries do not enjoy. That ruling was made given the need to preserve security of electricity supply in a market that is increasingly, but not yet securely, reliant on renewables generation.

EUROPEANIZATION OF THE ENERGIEWENDE: A CALL FOR PROACTIVE GERMAN ENERGY DIPLOMACY AT THE EU-LEVEL

The Commission ruling on Germany's strategic reserve offers another taste of what will be necessary for the long-term viability of the *Energiewende*: full integration of a single EU electricity market. The strategic reserve was approved on the basis of its being temporary, incentivizing Germany's utilities and policy makers to work together with their counterparts in neighboring countries to achieve a seamless and robust grid. The fact that German policy has made unprofitable nuclear and fossil generation assets obsolete without finding a substitute to provide those capacity services further underscores that more seamless grid integration beyond German borders will become even more important in the future.

Natural gas, which is a more effective fuel than coal for providing grid balancing peak services alongside renewables, will need to play a more significant role in the generation mix in Germany and throughout Europe in the context of a more integrated and distributed grid and increasing constraints on emissions.[29] The reforms of the EU ETS currently underway should clarify the market signal about increased costs for carbon-intensive energy production, which should disincentivize coal and make room for natural gas to return to the mix. But maximizing the cost-effectiveness of natural gas across the EU also requires advancing

a more diversified, transparent, and liquid gas market across the EU, and Germany should be more proactive in this effort.

Germany's history helped shape the country's commitment to a power sector transition that holistically integrates geopolitical factors, societal values, and economic requirements. Germany's experience with implementation to date shows the policy's resilience in the face of unanticipated consequences. Going forward, Europeanization of the *Energiewende* will be critical. Given the need for maximum integrity of the EU common market to achieve real efficiencies in energy security, economic competitiveness, and environmental sustainability, German competitiveness on a global level will be effective over the long term only if energy costs are made level across the European Union. To put it another way, European energy policy will need to be optimized to ensure German (and overall EU) industrial competitiveness in the face of low energy costs in North America and low labor costs in Asia.

And while other countries in the EU have vastly different visions for their energy mixes (consider the examples of France and Poland, which respectively champion nuclear and coal power), those differences will need to be reconciled, not ignored. Germany has not been a vocal supporter of the European Commission's Energy Union strategy, perhaps to avoid the policy contradictions that arise from it.[30] But Germany's experience with its *Energiewende* shows that contradictions are unavoidable and should even be embraced.

The different ideas on energy mix within the EU have to be brought into accordance.

Germany's historical experience explains how the *Energiewende* came about, and largely explains the resilience of the policies to abandon nuclear power and to scale-up renewables in the face of the challenges they have posed to Germany's consumers, utilities, and international competitiveness. The concept of Energiewende incorporates an assertion that Germany has been uniquely able to accomplish this transition given its geopolitical position, its social fabric, and the role of engineering and manufacturing in its economy. But given the need for better harmonization of the EU grid to maximize efficiencies, its ultimate success will require bringing the policy to an EU-wide scale. Germany has unsurpassed economic and political clout with which to lead this effort.

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GERMANY'S ENERGY TRANSITION: FROM A VISION TO A STRATEGY*

ANNIKA HEDBERG

INTRODUCTION

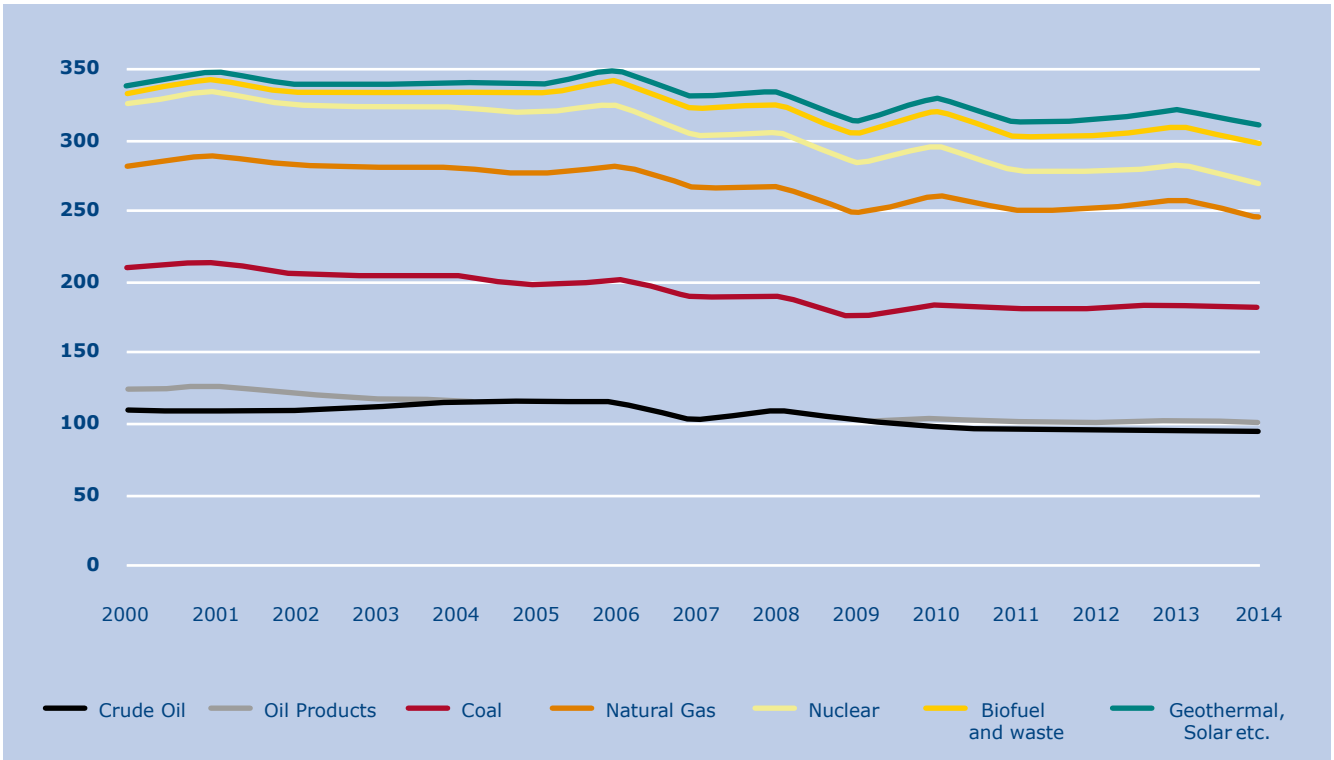
Germany's *Energiewende*, the energy transition, has received international attention, because of its ambitious goal to increase the share of renewables in the energy mix. Some have even portrayed it as a model for building a renewable future. The story, however, comes with shades of grey. While both the vision and the objectives are commendable, the implementation has been mixed. As a result, Germany's green energy transition and renewable revolution are still far from a reality.

A COMMENDABLE VISION

Germany's energy transition has been driven by its decision to abandon and replace nuclear power by 2022. At the same time, Germany has committed itself, for example, to reduce greenhouse gas (GHG) emissions by 40 percent by 2020 and up to 95 percent in 2050, compared to 1990 levels, and to increase renewables' share in (gross final) energy consumption to 60 percent by 2050. The German government's 2050 Climate Action Plan, adopted in November 2016, reiterates these objectives, and rightly recognises that not only energy but also other sectors, including transport and agriculture, should reduce their emissions.[1]

Germany can be credited for its vision and ambitious targets. Its GHG reduction and renewable targets for 2020 are higher than those agreed at EU level. Its sectoral targets for 2030 are commendable. Domestic initiatives, such as the building performance laws, have even been a source of inspiration for EU legislation.

FIGURE 1: GERMANY'S PRIMARY ENERGY SUPPLY IN 2000–2014 (IN THOUSANDS OF TONNES OF OIL EQUIVALENT)



Source: International Energy Agency[2]

* A longer version of this paper has been published in 2017 as an EPC Discussion Paper: Germany's energy transition: making it deliver, in: http://bit.ly/2i0odcm [10 Jan 2018].

GERMANY'S ENERGY TRANSITION IN FIGURES

The green energy transition is, however, still far from being a reality. Fossil fuels dominate as the main energy source (see Graph 1), and this can be explained by looking more closely at the electricity, heating and transport sectors.

In 2014, electricity was generated mainly using fossil fuels (56 percent), strongly dominated by coal (45 percent), but also relying heavily on gas (ten percent) and less heavily on oil (one percent).[3] This is comparable to Italy, where 55 percent of electricity is generated by fossil fuels.[4] In comparison, in France, fossil fuels account for less than five percent of electricity production which is generated mainly from nuclear energy.[5] In Germany, renewable electricity (accounting for 27.7 percent of power generation in 2014) came mainly from wind (nine percent) and biofuels (seven percent). Although solar tends to receive the greatest attention, its contribution is limited (5.7 percent), as with hydro (four percent) and waste (two percent). Since the 2011 Fukushima accident, the country has shut down nine of its 17 reactors, and nuclear's share in the electricity production has reduced from 22 percent to 15 percent.

The proportion of fossil energy to the electricity generation in Germany is comparable to Italy.

Given that heating accounts for around 50 percent of Germany's final energy consumption, the sector's continued reliance on gas (42.5 percent) and coal (33 percent) is striking.[6] In comparison, in Sweden, only eight percent of heat is produced by coal and three percent by gas – the main sources are biofuels (54 percent) and waste (23 percent).[7] In the transport sector, Germany is no exception to the rest of the EU. Renewables are a marginal source and fossil fuels make up 94 percent of the energy consumed. As discussion on renewable generation is often simplified into a discussion on photovoltaics and wind, it is worth noting that in Germany, bioenergy accounts for 85 to 90 percent of renewable final energy consumption in heating and transport.[8] Burning of wood is the dominant renewable fuel in the heating sector.

UNDERSTANDING THE ENERGIEWENDE WITHIN THE EU FRAMEWORK

It is often forgotten that the German energy transition does not happen in isolation. Germany is the EU's largest energy consumer, accounting for 19.5 percent of the EU28 energy demand in 2014.[9] Its GHG emissions account for more than 20 percent of the EU's total.[10] Geographically located at the centre of Europe, Germany's energy system is interconnected with its neighbours. Germany is an important player in the EU's internal energy market, which aims to ensure that energy – be it gas or electricity – can flow freely across borders without technical or regulatory barriers. Whatever Germany does thus has a direct impact on its neighbours and vice versa.

At the same time, the EU provides the framework and drivers that influence the *Energiewende's* success. While Germany shapes the commitments and measures taken at the EU level, they also have implications for it. Germany together with the other 27 member states have agreed on a vision to achieve more secure, cheaper and sustainable energy, and couple this with forward-looking climate action in Europe. They have agreed to build an Energy Union that puts priority on energy security, completion of the internal energy market, increasing energy efficiency, decarbonising the economy, and promoting research, innovation and competitiveness. An important part of the EU's climate and energy policy framework are the targets for 2020 and 2030 (see table 1).

Ensuring that Germany's national policies are aligned with the EU objectives is key to addressing shared challenges and achieving commonly agreed climate and energy targets. Sharing resources and developing regulatory frameworks with other member states can encourage sharing of best practices, help build a more reliable domestic energy system at lower costs, and balance fluctuating power generation. Connecting national energy markets and enabling EU-wide competition would reduce energy costs.

The EU context for Germany's energy transition has not been sufficiently acknowledged. In some aspects, German measures even contradict EU objectives. The *Energiewende* was launched with little consideration for its cross-border ramifications and

TABLE 1: EU'S CLIMATE AND ENERGY TARGETS

	20/20/20 targets for 2020	2030 climate & energy framework
GHG emission reduction (compared to 1990 levels)	20 %	40 % (minimum)
Share of renewables in energy consumption	20 %	27 %
Increasing energy efficiency	20 %	27 %

without consulting the other member states, and German national measures continue to create European-wide challenges, for example, on the following four accounts:

1. Due to the intermittent nature of solar and wind generation and the lack of storage solutions, Germany's neighbours have become buffers for its fluctuating renewable electricity production. These fluctuations impact grid stability, and thus place a burden and cost on neighbours. In theory, the free flow of electricity across borders is the internal energy market's key objective, and cheaper electricity exports from Germany should be positive since they can lower prices for neighbouring countries' consumers. However, as long as there is no functioning electricity market, it is in Germany's interest to put in place adequate power lines nationally, linking the north, where renewable electricity is mainly produced, to the south, where the big industrial consumers are located.

2. From an environmental and health standpoint, the air pollution generated by burning coal is not constrained within borders. Four out of the five largest industrial polluters in Europe are German lignite plants that run near full capacity for most hours as back-ups for renewables, keep the country's emissions high with implications also for neighbouring countries.[11]

3. Germany's plans to further increase imports of Russian gas (Nordstream 2) to replace coal as a back-up for renewables have raised not just energy security questions for the EU, but also wider political, legal and economic concerns.[12] Germany is already the EU's largest importer of Russian gas. Increasing this reliance via an existing route would run counter to the EU's efforts to diversify routes and suppliers. Against the backdrop of Russia's invasion of Ukraine, there are fears that increasing the share of Russian gas in Germany to 60 percent could give Moscow greater political leverage over Germany and thus the EU as a whole. Germany's push for Nordstream 2 is dividing the continent at a time when more unity would be needed

4. Given Germany's major role as a car – and namely diesel car – manufacturer means that the measures in the sector are felt well beyond national borders. Diesel emits more NO_x pollution, more tiny particles, and according to a recent study also more CO_2 emissions than petrol.[13] While the German car industry has benefited from European-wide support for diesel cars, the resulting air pollution has had significant impacts on people's health.[14] In the aftermath of "Dieselgate", which revealed large scale cheating by German and other European car manufacturers and shed light on the worse than expected real life on-road emissions, there is increasing pressure on the industry to transform. A major question for the German car industry now is whether it will join or oppose the change – and whether German government will end its protection of the car industry and implement concrete measures to reduce transport emissions.[15]

LESSONS LEARNED

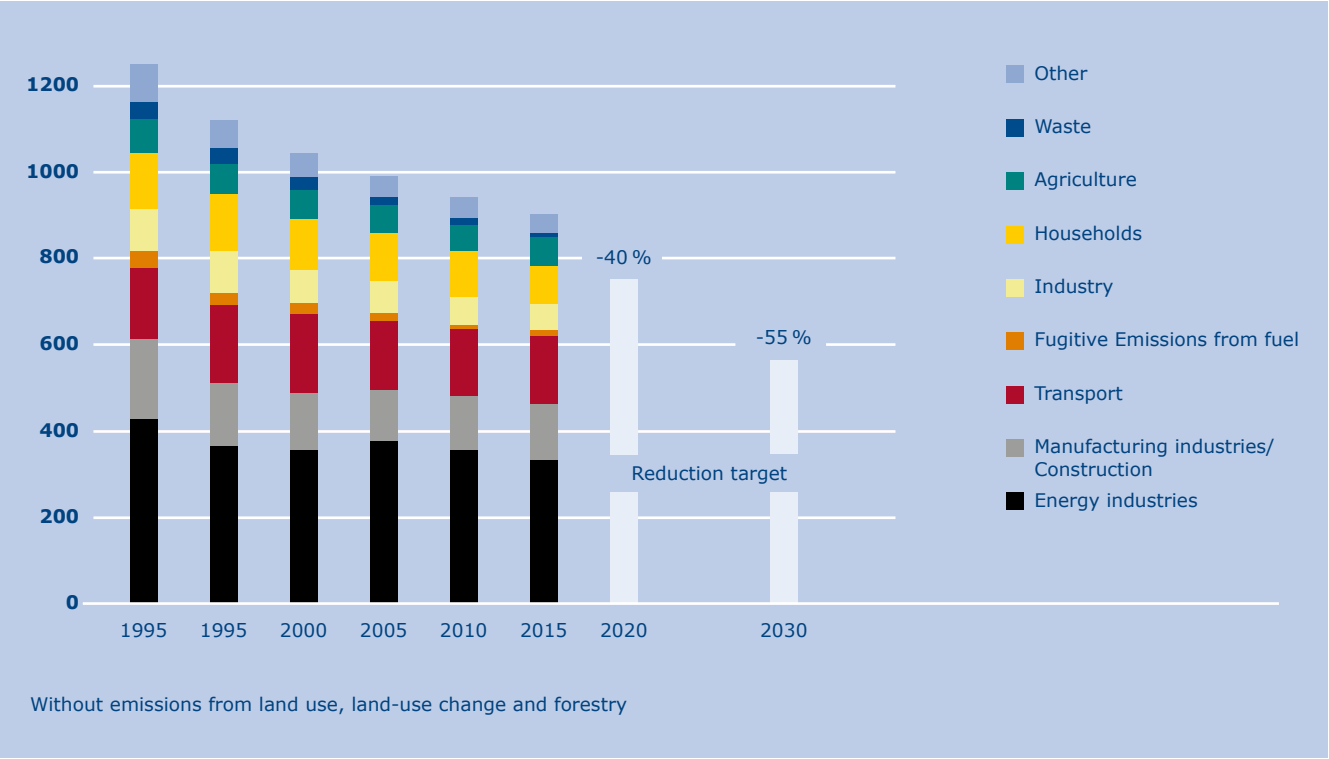
Germany's *Energiewende* has been about electricity – not energy – transition, which has led to a number of unwanted consequences. Little has been done to bring about an energy transition in the heating and transport sectors. Efforts to improve energy efficiency have been insufficient. Dependence on energy imports has not decreased. While there is a case for starting an energy reform with the power sector, a lack of a comprehensive energy transition strategy explains why greenhouse gas emissions have not declined significantly in the past decade (see Graph 2). Because of the reliance on fossil fuels, Germany is expected to miss its 2020 GHG emissions reduction target of 40 percent and cut emissions by only 30 percent.[16]

Many in Germany consider the *Energiewende* a success story in terms of renewables. Germany has indeed invested greatly in renewables.[17] The share of renewable electricity has also risen significantly during recent years. Today, renewable electricity generation, such as onshore wind and hydropower, can already compete with fossil-fuel fired power generation on costs. Solar is increasingly competitive too. After a high upfront investment costs (which are rapidly falling), operational and maintenance costs are low compared to coal. However, the investments have not always been cost-efficient, well-reflected in the solar cells' sub-optimal deployment supported by subsidies and inadequate infrastructure for integrating the renewables. Figures from 2014 show that subsidies for renewables cost German consumers annually 23 billion euros.[18] The *Energiewende's* cumulative cost could exceed 25,000 euros for a four-person household by 2025.[19] Relative to the cost of other goods and services, German households pay the most for electricity in the EU.[20]

The lack of an Energiewende-strategy explains why the CO_2 emissions didn't decrease significantly.

The greatest challenge Germany needs to address is its contradictory reliance on fossil fuels. Its coal dependence – it is a major importer and a producer, with significant lignite reserves – has negative implications for Germany and the rest of the EU. While gas is often promoted as a transition fuel, increasing gas consumption raises concerns, especially if this is done by increasing dependence on Russian gas. One can also challenge the investments' economic viability if these fail to recognise climate and

FIGURE 2: GERMANY'S GREENHOUSE GAS EMISSIONS AND CLIMATE TARGETS 1990 - 2030 (CO2 EQUIVALENTS IN MILLION TONNES)



Source: a graph by Clean Energy Wire[21] with figures from German Environment Agency[22]

energy trends and objectives. Furthermore, much work remains to be done if Germany wishes to be at the forefront of the transport transition, which includes the sector's electrification

Many of the challenges have now been officially acknowledged and Germany's 2050 Climate Action Plan is a step towards correcting some of the mistakes made and taking a comprehensive approach. Yet, implementation will be pivotal and the work has only just begun. Public knowledge and debate leave more to be desired. Moreover, strong opposition from industry can be expected when the vision is translated into concrete measures to reduce coal-fired power generation or transform the transport sector.

REFLECTIONS FOR THE WAY FORWARD

Reducing energy-related GHG emissions, increasing energy security and carrying out a cost-effective and sustainable energy transition would benefit from the following measures:

- Developing an exit plan from coal and a date for coal phase-out.[23] The government must reduce lignite use and remove the most polluting power plants. It must launch a constructive dialogue with key stakeholders about the rationale, vision and operational measures for a fair transition. It should ensure that the closure of its remaining nuclear plants in southern Germany will not be followed by increasing coal-generated electricity imports e.g. from the Czech Republic, which is currently enhancing lignite excavation.

- Ensuring that the people and industry have the knowledge, skills and the tools to remain committed to the transition. Germany should encourage citizens and industries to adapt their energy demand to the available electricity supply.

- Using the current low oil and gas prices as an opportunity to raise taxes on both, and taking the extra revenue to support transition into a greener energy system. Germany should increase energy efficiency and exploit alternative domestic energy sources, including combined heat and power systems, heat pumps, and geothermal systems.[24]

- Supporting investment in solar and wind only in places where they make sense, and building the needed domestic grid infrastructure. Germany should collaborate with other EU member states in developing and deploying renewables and storage solutions.

- Ensuring that the renewables targets will not be met by simply increasing biomass use in a non-sustainable way. Germany should aim to ensure that the current review of the EU's Renewable Energy Directive will not incentivise burning advanced bio-based raw materials for energy if these could be used for higher-value purposes and/or their use for energy leads to unwanted emissions.

- Having much more critical and future-oriented domestic discussions on gas. Germany should acknowledge and openly discuss the political, economic and legal concerns surrounding the Nordstream 2 gas pipeline as well as its implications for the EU's energy security. Investments in new gas infrastructure should be based on joint efforts to understand not national but European future demand in the power, transport and heating sectors. If Germany can justify the need for additional gas imports, and is willing to invest in the required infrastructure, why not explore alternative routes and suppliers in line with the EU's energy security plans? Options include Norwegian gas or liquefied natural gas (LNG) imports from the United States and the Gulf.

- Recognising that the German car industry's future depends on whether it can rapidly transition out of fossil fuels. Voluntary retrofits to diesel cars as suggested by the industry is not the answer.[25] The government must resist the temptation to protect the car industry and undermine EU efforts to place stricter car emission standards. The significant environmental and health impacts must be addressed head on. More comprehensive vision and measures are needed to push for low-emission mobility.

CONCLUSIONS

While in its current form Germany's *Energiewende* does not provide a model for others to follow, its experiences provide valuable lessons. The German example recalls the importance of a comprehensive vision for a sustainable energy system and an all-inclusive strategy for its achievement, which are in line with the EU objectives and implemented in coordination with other member states .

The German example recalls the importance of a comprehensive vision for a sustainable energy system and the importance of an all-inclusive strategy.

Germany could be a key player in leading climate action not only in Europe but globally. However, it can provide a credible and attractive model for others only if it can prove that the transition can be cost-effective and deliver in parallel on reducing global emissions, tackling local air pollution, securing energy supplies, promoting wider socio-economic interests and increasing competitiveness.

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GERMANY'S ENERGY TRANSFORMATION: IT'S NOT EASY BEING GREEN

SYED NAZAKAT

The *Energiewende* was dreamed up in the 1980s, became policy in 2000 and sped up after the Fukushima disaster in March 2011. The *Energiewende* a is long term plan by Germany to restructure its energy sector, shifting from current nuclear and fossil fuels to renewable sources of energy. The *Energiewende* means Germany will have no nuclear plants by 2022, and the country will have 40 to 45 percent of total power generation coming from renewables by 2025, 55 to 60 percent by 2035 and 80 percent by 2050.

In contrast to a post-Fukushima Germany, the predominant view in many countries, including here in India, is that nuclear energy is the only option to self-sufficiency. The Fukushima nuclear disaster was seen as a natural catastrophe, happening once in a century and, with safety guidelines in place, is preventable. This is the reason why, after a short duration, even Japan returned to nuclear energy. And while other western countries were not thinking of discontinuing with nuclear energy, Germany became the only country taking a snap decision to announce a shutdown of all its nuclear reactors by 2022 rather than a more gradual phase-out. Seven reactors were shut down immediately as a result of Chancellor Merkel's announcement. A lot therefore depends upon the success of Germany's *Energiewende* for developing economies of the world to set down plans to emulate it.

In case of India, which currently has 21 operating nuclear reactors at six locations with combined capacity of 5.8 gigawatts, there is a view that nuclear energy is major route to secure the future of a perpetually energy starved country. Population growth in India is phenomenal so that by 2050 almost one in five people on earth will be Indian. A dominant view propelled by the mainstream media is that it will be a difficult to provide energy for so many people for their homes, schools, and offices without fully banking upon nuclear energy. Presently, India consumes the equivalent of 872 million tonnes of oil for power with an annual energy import bill of 120 billion US dollars. By 2040, it will have grown to one trillion US dollars according to a World Energy Outlook report. This is the reason why the Indian government has presented nuclear energy as part of the solution to its energy crisis. In such a scenario the *Energiewende's* success is likely to serve as motivation for countries like India, which are keen to diversify their energy resources to fulfill growing energy demands. Like Germany, India has ambitious energy plans. While Germany has a policy of clean energy, India has a long term plan for its nuclear sector. India wants to have a total of 470 gigawatts installed by 2050, equating to more than today's entire global nuclear capacity.

THE ENERGIEWENDE: A GERMAN PECULIARITY

I wondered as I travelled in Germany in early 2016: Why is Germany so keen to close all its nuclear reactors and instead shift to clean energy? What is the scale of the changes unleashed by the *Energiewende* and their long-term impact? And whether Germany's success in renewables could happen everywhere? Along the Berlin–Hamburg road we saw solar and wind farms. At the Port of Hamburg, Europe's second largest port and considered the gateway to Asia, wind energy is increasingly used for electricity and heating. Across Germany, solar panels cover the roofs of homes. Every kilowatt-hour earns house-owners money. A law passed in 2000 grants people what's known as a feed-in tariff for the power they deliver to the grid. It adds up to about 40 US dollars a month, and it's guaranteed for 20 years. Today, more than 1.4 million German households and cooperatives are generating their own solar and wind electricity. More than 1.5 million renewable power plants have been installed in Germany since 1990. Currently, roughly 33 percent of Germany's electricity is from renewables. Their generated power is the first to be sold on the electricity spot market due to the low cost of operation compared to conventionally produced electricity.

German consumers pay the second-highest electricity prices in Europe – and are still in favor of the Energiewende.

As a consequence, German consumers pay, in relative terms, the highest electricity prices in Europe. The people have seen their electricity bills double since the introduction in 2000 of a renewable-energy levy, slapped on every household's electricity bill to subsidize the owners of wind turbines and solar panels. Today, Germany has, in absolute terms, Europe's second highest consumer electricity prices and still a good majority of people in the country want the *Energiewende*. The economic involvement of the general public is at the heart of the German *Energiewende's* popularity and success. And the support to renewables is rooted in Germany's eco-friendly culture and a long history of environmental activism, a collective desire to abandon nuclear energy.

OPPORTUNITIES AND CHALLENGES

The impact of the *Energiewende* on the economy is viewed, above all, through the number of jobs created. According to a study commissioned by the Federal Ministry of Industry and Energy, about 371,400 jobs (2013) stem from renewable energy production and supply, the manufacturing of power generation hardware, related R&D, and servicing renewables generation facilities. The German Industry Initiative for Energy Efficiency (DENEFF) calculates 848,000 jobs (2013) stem from the energy efficiency push.

It's hard to see how Germany can avoid increasing its coal use dramatically after it phases out nuclear power.

But this push towards renewable source of energy and new fossil-fuel power plants has resulted in overcapacity and caused wholesale prices to fall, which has battered the utilities' profits. This energy mismatch led to the German government finally deciding to scrap the existing system of administered prices for wind and solar power. Instead, since January 2017, it operates competitive bidding systems in which the right to develop a particular wind or solar project will go to whichever credible bidder agrees to accept the lowest revenue per kilowatt hour on a 20-year contract. It is important to underline that investment in solar and wind is high at the beginning, but costs reduce considerably when the systems have been purchased and installed. These features have led to fundamental shifts in the power market with Germany also having to integrate renewable energy into its energy infrastructure. Fluctuating supply has required upgrades in the entire power grid with an investment of 35 billion euros for the construction of high voltage transmission lines – electricity autobahns – to carry energy from the wind rich north to the industrial regions, and also requiring excellent forecasting tools and battery technology.

CONCLUSION

For Germany, the challenge remains on how to phase out nuclear in the coming years. Today, nuclear provides about 18 percent of Germany's production and is still the country's largest low-carbon source by far. What they replace it with will determine the direction Germany's energy transition will take. Germany is currently the eighth largest coal producer in the world and it's hard to see how Germany can avoid increasing its coal use dramatically after it phases out nuclear power.

One thing that is clear is that Germany, unlike most countries, has undertaken a bold plan for a clean-energy future. The country has done remarkably well so far in its journey on the road to clean energy. It has created a world-class renewable industry, tens of thousands of jobs, and in the process it has initiated an energy transformation which could become a model for how we all get electricity in the future. The energy system is very complex and poses a serious challenge for an economic power like Germany to suddenly change its energy approach. The question then becomes, which of Germany's objectives will be sustained, and which will be abandoned over the long run in its pursuit for clean energy? Whatever the paths and decisions Germany takes, it may give some direction to how we all get power in the future.

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THINKING ABOUT THE GERMAN ENERGIEWENDE: AN OUTSIDE VIEW ON THE CHALLENGES AND OPPORTUNITIES AHEAD

LIXIA YAO

The German *Energiewende* is an aggressive transition to renewable energy. If successfully arranged and implemented, the German *Energiewende* can set an example of how a highly developed economy, which has been heavily dependent on fossil fuels and nuclear power, evolves to a sustainably green one. This essay discusses, from an outsider's view, the experiences of the German *Energiewende*, the challenges it is facing as well as new opportunities ahead.

PAST EXPERIENCES: DID GERMANY DO WELL?

Past experiences show that renewables are able to substitute a significant volume of nuclear and/or fossil power plants in Germany. Renewables have surged in the country measurably since the adoption of the Stromeinspeisegesetz (literally the "energy feed in law") in the early 1990s. 2015 in particular was said to be a banner year for Germany's renewable energy sector, as the renewable producers added more new generation than ever before in a single year,[1] thanks to the German feed-in tariffs (FIT), which have been subsidizing renewables development for more than two decades. Exertion of political influence has led to a significant increase in renewables as well. Some federal laws have supported and/or subsidized renewable energy development, nuclear energy has been banned for further expansion, but subsidies have resulted in a sharp increase in electricity prices.[2]

FROM FEED-IN TARIFFS TO AUCTIONS

The *Erneuerbare-Energien-Gesetz* (EEG), otherwise known as the Renewable Energy Sources Act, specifies the FIT regulation and hence supports one of the main pillars of the German *Energiewende* – switching power generation from nuclear power and fossil fuels almost entirely to renewables. The FIT under the EEG has made the German *Energiewende* unnecessarily expensive. The German government has amended the EEG several times, the last time in July 2016. Substantial changes have been made. One major change is the transition from a FIT to an auction system in renewable energy development. The transition is fine in the sense that it is good for marketization in the development of renewables and it avoids an excessive renewable capacity increment that does not align with the power grid extension. However, the disadvantages are also obvious. Almost half of the renewable capacity has so far been contributed by individuals and small cooperatives that are not well positioned to compete in auctions so whether the latest amendment in the EEG is beneficial for the German *Energiewende* remains to be seen. What is worrisome is that the newly-reformed EEG may turn the *Energiewende* into a project for large companies while making individuals and small cooperatives big losers in the reform. While participation by individuals and small cooperatives is crucial to maintaining public support for renewables and overcoming local protests against specific renewable projects such as wind farms, the effect could be slow-down of development of renewables. However, several types of subsidy for small cooperatives meant they gained a positive result in the first auction rounds for wind energy. Germany's ambitious target of emissions reduction would be even harder to achieve if renewable energy development slows down. The amendment may bring renewables 'closer to the market', but make emissions reduction farther away from its stated targets. In one sentence, the EEG reform is good for costs reduction but other effects, either positive or negative, remain to be seen.

The participation by individuals is crucial to maintaining public support for the Energiewende.

WHERE ARE THE CHALLENGES?

The EEG has been successful in terms of an increase in electricity generation from renewables. Since coming into force in 2000, the share of renewable electricity in gross electricity consumption increased from 6.2 percent in 2000 to 31.6 percent in 2015. However, the growth of renewable electricity generation comes with a substantial increase in the volume of financial support. In 2016, the aggregate EEG surcharge amounted to 22.9 billion euros. In other words, the *Energiewende* has been enforced at a cost of significantly increased electricity prices. As a result, many energy-intensive industries and firms have been exempted from the surcharge to keep them internationally competitive, thereby substantially increasing the burden on private households. An average household in Germany paid doubled electricity price in 2013 compared to the price in 2000, while at the same time, the EEG surcharge skyrocketed from 0.25 euro cents per kilowatt hour in 2001 to 6.35 euro cents per kilowatt hour in 2016.[3] This raised the question of how the poor would continue to pay their power bills. Hence, there

was an urgent need to find a solution for electricity consumers, especially large-scale electricity users. In 2014, the EEG was reformed to introduce a tendering system for PV plants and, as mentioned above, an auction system for all renewables has been in place since 2017, but it remains to be seen whether the increase in development costs are to be accepted or carried by the renewable producers. Considering the costs are passed onto the consumers, it also remains to be seen how long citizens will be willing to support the energy transition. In other words, Germany is faced by the challenge of whether the economy can afford energy transition. The government must therefore very carefully reform the subsidies policy to ensure the relevant policies can provide Germany with the sustainable competitive advantages critical to the success of the German *Energiewende*.

The government has to take into consideration the *Energiewende's* "European dimension". Germany is not a closed entity. This is true also for the electricity market. Germany is reliant on its European neighbors' energy policies when trading electricity with them. Therefore, the *Energiewende* is not only a national issue but has to be discussed and coordinated on a supranational level. However, it must be kept in mind that a full and immediate centralized Europeanization of the *Energiewende* is not yet possible, and neither is the EU-wide optimization of energy transition policies. The immediate challenge is to optimize the decentralized cooperation among member states and to ensure reliability in transmission and distribution in an interconnected European market. On top of this, it should also be kept in mind that phasing-out nuclear energy must be complemented with a corresponding increase in renewable deployment so as to avoid substituting domestic with imported nuclear power. It also needed to be ensured that the phase out of nuclear energy must not be imposed on neighboring countries where nuclear power is in use. Bilateral negotiations (such as with France and the Czech Republic) on near-border power plants may be needed.[4]

The Energiewende has to be discussed and coordinated on a supranational level.

Furthermore, in the German domestic electricity market, the elaborate planning process for power expansion and modernization is too bureaucratized. A lack of transmission infrastructure is one of the biggest challenges the German *Energiewende* has to address. As there is an imbalance between energy supply and demand in Germany, the government must find a way to ensure that power generated in the Northern Germany from renewables such as wind power can be transferred to the power-hungry South. The power grid extension can also stabilize the German electricity grid so as to adjust the fluctuations of renewable energies and to integrate the increasing number of decentralized generation capacities. Although there has been initiation with this regard, the process is currently still behind schedule.[5]

Technology is another key issue. In Germany, the renewables that have large growth potential are solar and wind resources, both of which are very volatile. There is an urgent need to construct new power grids, which is time-consuming and requires heavy investments. Due to the lack of efficient energy storage technologies, renewable energy is, in the near future, far from being able to replace fossil fuels in Germany. This constitutes one of the greatest challenges to Germany's energy transition. As Germany's main sources of renewables are decoupled from the centers of demand, efficient and reliable energy storage technologies are badly needed. The existing technologies are either far from commercialization or subject to topographical restrictions. However, the government lacks technical and project competencies that are necessary to govern and monitor the R&D of those technologies in need.[6] The lack of refined storage technology makes it impossible to store energy generated from renewables more effectively during peak times and to optimally use it when needed.

IMPLICATIONS AND OPPORTUNITIES FOR THE FUTURE: HOW CAN THE GERMAN DO BETTER?

First and foremost, the EEG reform is a logical next step for renewables. On the positive side, the reform ensures that the most economically efficient projects will be developed so that total costs will be lowered. The reform will release the *Energiewende* from the burden of almost totally focusing on renewables development to addressing other challenges such as decarbonizing the transport sector. On the negative side, the auction system will increase financial risks for investors. The result may be insufficient numbers of investors participating in the auctions. Furthermore, if investors win an auction but postpone construction for whatever reason, growth corridors for renewables will be missed. The growth corridors for renewables stipulated in the reformed EEG seem quite low, making it difficult to achieve Germany's climate targets. It seems that Germany's renewable deployment targets fall short of its climate targets. Therefore, an immediate task is to redesign the German electricity market so that the lower renewable electricity prices brought by the revised EEG can be passed on to consumers.

Second, an important pillar in the success of energy transition is to reduce energy consumption through improving energy efficiency. Therefore, a successful energy transition has to address not only supply but also demand sides. More incentives have to be in place for the benefit of demand-side management. With this in mind, opportunities exist in active energy policies that stimulate energy efficiency. Altogether,

the move towards a regenerative energy supply as well as efficiency-based reduced energy demand will make Germany more innovative and competitive, which may offer huge export opportunities in the long run.

Third, extending the electricity grid and designing a new market is important for achieving the *Energiewende*. The new market needs to integrate renewable and other options such as demand-side management and to ensure economic viability of conventional generation capacities. The cost recovery of grids is also be incorporated in the market design. Cost efficiency needs always to be taken into account when setting any targets or implementing any specific projects, whether developing a new electricity grid or designing a new market.

SUMMARY AND CONCLUSION

The German *Energiewende* is successful in the sense that renewables have surged in Germany in the past decade. The sharp increase of renewables is largely attributable to political decisions and regulatory support such as subsidies. The FIT system specified in the EEG has made a major contribution to subsidizing the expansion of renewables in the country. However, FIT is a double-edged sword. The negative impact is a sharp increase in electricity prices, making the German *Energiewende* unnecessarily expensive. The German government therefore has amended the EEG this year to transit the FIT into an auction system. The amendment is good in terms of marketization of renewables development, yet it may discourage the involvement of individuals and small cooperatives in the German *Energiewende*. Other effects of the EEG amendment remain to be seen.

New laws need to be enacted to facilitate and speed up power grid expansion.

To make the German *Energiewende* an ultimate success, several challenges have to be addressed. The government has to ensure that the economy, including individuals and enterprises, can afford energy transition. A pan-European view is needed when implementing the *Energiewende*. Furthermore, the government needs to put more efforts into making the distribution of renewables consistent with power grid expansion. Currently, the grid expansion is not sufficient in contrast to the increased distribution of renewables. New laws need to be enacted to facilitate and speed up power grid expansion and modernization. New technologies are also urgently needed to facilitate the German *Energiewende*.

In any sense, Germany's *Energiewende* is not only energy transition but also energy revolution. Its success depends on whether and how the government can successfully respond to the challenges. The current efforts in reforming the EEG and in promoting energy efficiency have shown the government's determination to give more impetus to the *Energiewende*. When driving forward these efforts, it is necessary to review and modify policies on a continuous basis. In one sentence, the completion of Germany's *Energiewende* will be a task for generations. Hopefully it will set an excellent example and its mode can be generalized as much as possible and followed by as many other countries as possible.

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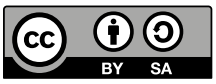

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