Lessons Learned from Germany's *Energiewende*: The Political, Governance, Economic, Grid Reliability, and Grid Optimization Bedrock for a Transition to Renewables

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The German example is rife with lessons – pertaining to politics, governance, economics, grid reliability, and grid optimization – for other countries, such as the United States, to internalize as intermittent renewables become more prevalent in their generation mixes. The German example reveals that, while aligning politics and governance structure for an energy sector transition is a heavy lift reliant on sustained popular sentiment among the public, implementation can occur quickly once these pieces are in place. Economic lessons are nuanced. Macroeconomic costs of Energiewende have placed substantial burdens both on energy-intensive industries and on residential consumers. Associating as an Energiewende proponent requires belief that macroeconomics benefits – such as large employment gains and the establishment of significant market share in an already large industry that's poised to boom – as well as microeconomic indicators, such as rapidly declining prices for renewables, justify such high short-term costs. Regarding reliability, the German example shows that a grid that derives over a quarter of its power from renewables can become a global leader in supply security given ample reserve capacities and well-developed interconnections with neighbouring grids. However, extensive and expensive transmission and distribution (T&D) infrastructure must be built to minimize renewables-induced grid congestion that threatens grid reliability both domestically and for neighbours.

I. Introduction

As the home of Einstein, Nietzche, Beethoven, Heisenberg, and many other iconic academic and artistic game changers, it should come as no surprise that Germany is at the forefront of modernizing an industry as complex as energy.

Energiewende – the "transformation of Germany's energy supply system to renewables" through juxtaposing over 20 different quantitative, energy-related targets,[1] presented in Table 1 (see Annex) – is a "mammoth policy project"[2] and by far the most aggressive clean energy effort among the G20. While *Energiewende* comprises energy efficiency, nuclear phase out, and emissions targets, this paper focuses on its goals for renewables fuelling the electricity sector.

The law catalysing Germany's energy transition is the "Renewable Energy Sources Act" (EEG), the first iteration of which was passed in 2000. *Energiewende* was later conceived in September 2010 when the Federal Government adopted the *Energy Concept*, which was revised in 2011 after the Fukushima meltdown inspired the German government to cut nuclear power from its envisioned electricity

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1 Federal Ministry of Economic Affairs and Energy. "The Energy of the Future." (Germany.info, December 2014) <http://www.bmwi.de/English/Redaktion/Pdf/fortschrittsbericht-kurzfassung-en,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf>accessed 18.03.2015.

2 Lars Dittmar, 'Generation in Germany under Decarbonisation: The German 'Energiewende',' (TU Berlin Department of Energy Systems, November 2013) <http://www.iea.org/media/training/bangkonov13/session_4b_germany_generation.pdf>accessed 18.03.2015.

mix.[3] While *Energiewende* has forged ahead "essentially on the basis"[4] of the 2010 Energy Concept and its 2011 revision, an August 2014 reform "fundamentally overhauled" the EEG, restructuring it to enable the achievement of *Energiewende*'s goals in a more affordable manner.[5]

A little over a decade after the EEG and just a few years after *Energiewende*'s birth, the German energy landscape has been completely transformed. Renewables' share in Germany's electricity generation has increased from seven percent in 2000[6] to close to 28 percent during 2014,[7] double America's 2014 renewables percentage, about 13 percent.[8]

If successful, *Energiewende* can serve as a blueprint for expediting the broad scale integration of technologies that will be necessary to wean the world off fossil fuels and combat climate change.[9] So far, the German example has revealed that, while aligning politics and governance structure for an energy sector transition is a heavy lift requiring robust agenda-setting efforts, implementation can occur quickly – and with macroeconomic benefits that include boosting net employment and winning market share in a budding sector, albeit at a high financial burden – once these pieces are in place.

This article examines lessons learned from the German experience from a frame of how they might apply elsewhere, with a focus on the United States. It is broken into sections that focus on politics and governance, economics, and grid reliability and optimization.

II. Politics Governance

Political actors in countries with coordinated market economies, such as Germany, prefer dialogues, strategic concessions, and trade-offs that give rise to policy decisions unanimous among main stakeholder groups. However, for *Energiewende* unanimity is constrained. That's because two interest groups, the Conventional Energy Coalition (CEC) and the Sustainable Energy Coalition (SEC), support fundamentally different energy systems that oppose each other.

The CEC strives "to maintain the status quo of the energy system."[10] A critical mass of major CEC proponents hold a financial stake in the current energy system, and CEC arguments centre on risks – such as potential grid reliability problems, as well as high costs eroding the country's industrial sector's global competitiveness – inherent in pioneering a shift away from a century-old paradigm.[11]

Opposing the CEC, the SEC's foremost ambition is for *Energiewende* to maintain momentum and the transition to renewables to occur in a timely and strategic manner. (See Tables 2 and 3 (see Annex) for more information on CEC/SEC political stances and leadership,as well as German political parties' positions on *Energiewende*).[12]

At the federal level, six ministries have relevant jurisdictions concerning the *Energiewende*. The three most important actors are the Federal Ministry of Economics and Energy (BMWi), the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the German Network Agency (BNetzA). While there has been recent progress in clarifying ministries' authorities, there is still overlap among ministries' responsibilities. For example, 'energy efficiency' improvement is an objective for the BMWi and BMUB, as well as for the Federal Ministry of Transport and Digital Infrastructure (BMVI).[13] At present, Barbara Hendricks and Sigmar Gabriel are ministers leading the BMUB and the BMWi, respectively. Both are

3 Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, 'The Federal Government's energy concept of 2010 and the transformation of the energy system of 2011' (Germany.info, October 2011) <http://www.germany.info/contentblob/3043402/Daten/3903429/BMUBMWi_Energy_Concept_DD.pdf> accessed 15.01.2015.

4 BMWi (n 1).

5 Ibid.

6 Dittmar (n 2).

7 Federal Ministry for Economic Affairs and Energy, 'Renewables now account for 27.8% of Germany's final electricity conusmption' (Germany.info, March 2015) < http://www.bmwi.de/EN/Press/press-releases,did=695286.html> accessed 18.03.2015.

8 U.S. Energy Information Administration, 'Electric Power Monthly with Data for December 2014' (U.S. Department of Energy, February 2015) <http://www.eia.gov/electricity/monthly/pdf/epm.pdf > accessed 18.03.2015.

9 Kirsten Westphal, 'Globalising the German Energy Transition' (German Institute for International and Security Affairs, 2012) <http://www.swp-berlin.org/fileadmin/contents/products/comments/2012C40_wep.pdf > accessed 15.01.2015.

10 Claudia Kemfert and Jannic Horne, 'Good Governance of the Energiewende in Germany; wishful thinking or manageable?' (Hertie School of Governance, July 2013) <http://www.hertie-school.org/fileadmin/images/Media_Events/BTW2013/20130820_Good_Governance_of_the_Energiewende_in_Germany_ClaudiaKemfert_Download.pdf > accessed 15.01.2015.

11 Ibid.

12 Ibid.

13 BMWi (n 1).

members of the Social Democratic Party (SPD), a political party that aligns itself in the middle between the SEC and the CEC, but leans SEC. For details on the *Energiewende* responsibilities of the relevant federal ministries and other governing bodies, refer to Table 4(see Annex).[14]

According to the BMWi, *Energiewende*'s approval rating is between 56 and 92 percent,[15] and, according to Bloomberg New Energy Finance (BNEF), "67 percent think the country isn't doing enough to move to renewables."[16]

Despite being vastly outnumbered, the CEC continues to fight the energy transition. This state of affairs reveals the importance of political stamina in the energy transition context. The German government understands the importance of *Energiewende's* popularity in moving it forward, and BMWi emphasizes consistent and transparent communication with the public, as well as affordability, as crucial "actions to sustain the popularity of its energy transition."[17]

Political stamina becomes doubly relevant when considering the governance challenges *Energiewende's* implementation presents. *Energiewende* comprises diverse political levels and jurisdictions – global, European, federal, state, and municipal – as well as interest groups, cooperatives, alliances, banks, and individuals. To this end, BMWi asserts that "only through effective coordination with the German Länder and close collaboration with actors from business and society will it be possible to successfully transform our energy sector."[18]

Partisan politics renders individual governing bodies' positions dynamic; and, thus, how the moving parts of an energy transition work together as a unit frequently fluctuates. While *Energiewende* is a program with long-term 2050 goals, the heads of these governing ministries fluctuate more regularly; since *Energiewende's* official start in 2010, there have been 3 different heads of the BMWi. The political leanings – specifically, whether ministers are proponents or opponents of *Energiewende* – of these ministries in the future is an unknown that will impact the efficiency and effectiveness of *Energiewende's* implementation.[19]

This state of affairs reveals inherent risk from when an ambitious energy transition with long-term goals relies on a sustained, favourable political backdrop. For future energy transitions elsewhere, it should be noted that there are ways to organize governance – such as creating administrative positions for appointees with indefinite terms, and/or delegating a greater share of power to independent stakeholders, such as BNetzA – that are less prone to the instabilities associated with partisan politics.

Germany's federalism adds another wrinkle of complexity to *Energiewende's* governance. States (Länder) have their own agendas; so, inconsistencies between federal and state goals are inevitable. To date, according to IEA, "many grid projects have been delayed or stopped at Länder borders." Beyond managing infrastructure at state borders, a concern of IEA "is competition between Länder for renewable developments, which provide a source of revenue to the host area."[20] For example, both northern and southern states would like to increase their supply of renewables, but all these states moving forward on this ambition could lead to over-capacities,[21] thereby stressing and potentially damaging transmission and distribution infrastructure, leading to reliability concerns.

While states have recently agreed to improve cooperation and relinquish more planning competencies to the federal level (the Act to Accelerate the Expansion of Electricity Networks in 2011 streamlined approval and transferred competencies from states to the federal government) unclear jurisdictions and lack of accountability are still prevalent and, thus, planning and implementation problems are likely to persist.[22] There must be a clear, accepted understanding that the higher level of government has authority, if conflicting agendas among lower levels of government arise.

14 Kemfert and Horne (n 11).

15 BMWi (n 1).

16 Angus McCrone, 'E.ON Split to Fortify German Green Energy Transformation' (Bloomberg News, 1 December 2014) <https://www.bnef.com/News/94282?fromGlobalSearch=1566360009> accessed 15.01.2015.

17 BMWi (n 1).

18 Federal Ministry for Economic Affairs and Energy, 'Coordination of the Energy Transition" (Germany.info, 2015) <http://www.bmwi.de/EN/Topics/Energy/Energy-Transition/coordination.html> accessed 18.03.2015.

19 Kemfert and Horne (n 11).

20 International Energy Agency, 'Energy Policies of IEA Countries: Germany 2013 Review' (OECD/IEA, 2013) <http://www.iea.org/publications/freepublications/publication/Germany2013_free.pdf> accessed 18.03.2015.

21 Kemfert and Horne (n 11).

22 IEA (n 21).

Along with ensuring state activities fall in line with the national *Energiewende* vision, the national government must steer *Energiewende* so that it is compatible with the plans for the European Union (EU). According to BMWi, "implementing the *Energiewende* in the context of the single European market for electricity and gas makes a close exchange with our neighbours and at the European Union level necessary."[23]

III. Economics/Costs

Critics consider *Energiewende*'s costs unjustifiable, arguing they hurt the country's international competitiveness and systemic inefficiencies exacerbate these costs. Supporters, by contrast, trumpet investments in *Energiewende* as having benefited employment rates, as well as the country's market share in a budding industry, and they believe that current costs will manifest as medium- and long-term net macroeconomic gains.

According to the European Commission (EC), "the expansion of renewable energies reaching a share of 63% by 2030 would result in additional costs of EUR 137 billion compared to a fossil-fuel based reference scenario."[24] BNEF estimates the total cost to date of Germany's clean energy expansion at €106 billion.[25]

Energiewende's costs primarily manifest via the 'EEG levy' – the difference between the set feed-in price for renewable energy sources and the trading price of electricity.[26] This levy amounted to €20.4 billion in 2013 and increased to €23.6 billion in 2014, reflecting EEG surcharges of €0.0528/kWh and €0.0624/kWh in 2013 and 2014, respectively. Recent wholesale and retail electricity price trajectories convey the financial impacts of Germany's electricity tariffs, of which the EEG comprised 37% in 2013; from 2008-2013, wholesale prices fell by 18%, while retail prices increased by 8%.[27] Eurelectric's explanation for this state of affairs is that, between 2008 and 2012, "taxes & levies rose by as much as 31%, wiping out any benefits derived from functioning wholesale markets."[28]

These costs burden energy-intensive businesses that compete in the global market. According to BMWi minister Sigmar Gabriel, "energy costs in industry amount to up to 60% of the total business costs (cellulose, paper)... In Europe, electricity costs are roughly two-and-a-half times as much as in America...

So you can see the danger that entire industries will relocate."[29] The European wing of the International Federation of Industrial Energy Consumers (IFIEC) echoes Gabriel's message, asserting that electro-intensive companies "will need to be shielded from these ever increasing costs."[30]

This 'shield,' at present manifests as significant EEG discounts for energy intensive industries; by September 2013, "2,295 companies and business components were exempt from the EEG levy."[31] A

23 Federal Ministry of Economic Affairs and Energy 'Second Monitoring Report 'Energy of the future'' (Germany.info, March 2014) <http://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/BNetzA/Areas/ElectricityGas/Special%20Topics/MonitoringEnergyOfTheFuture/Summary%20of%20the%20Second%20Monitoring%20Report.pdf?__blob=publicationFile&v=3> accessed 18.03.2015.

24 European Commission, 'Assessment of climate change policies in the context of the European Semester – Country Report: Germany' (EC, January 2014) http://ec.europa.eu/clima/policies/g-gas/progress/docs/de_2014_en.pdf.

25 Ashwini Bindinganavale, 'Renewables Take Top Share of German Power Supply' (Bloomberg News, 1 October 2014) <https://www.bnef.com/News/92136> accessed 15.01.2015.

26 Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 'Climate Protection in Figures' (Germany.info, June 2014) <http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutz_in_zahlen_broschuere_en_bf.pdf> accessed 18.03.2015.

27 Agency for the Cooperation of Energy Regulators, 'Public data underlying the figures of Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2013' (ACER/CEER, October 2014) <http://www.acer.europa.eu/Events/Launch-of-the-ACERCEER-Monitoring-report-on-the-internal-electricity-and-gas-markets-/Documents/Public%20data%20underlying%20the%20figures%20published%20on%20ACER%20CEER%20Annual%20Market%20Monitoring%20Report%202013.pdf> accessed 18.03.2015.

28 Eurelectric, 'Analysis of European Power Price Increase Drivers' (Electricity for Europe, May 2014) <http://www.eurelectric.org/media/154662/prices_study_final-2014-2500-0001-01-e.pdf> accessed 18.03.2015.

29 Sigmar Gabriel, 'German and Energy Policy: Special Path or International Role Model?' (Federal Ministry for Economic Affairs and Energy) <http://www.bmwi.de/EN/Press/speeches,did=638228.html> accessed 18.03.2015.

30 International Federation of Industrial Energy Consumers, 'Global competitiveness of European energy intensive industry & crucial exemption from decarbonisation surcharges' (IFIEC Europe, October 2013) <http://www.ifieceurope.org/docs/20131017%20IE_Letter%20to%20EU-Commissioners%20on%20Competitiveness.pdf> accessed 18.03.2015.

31 EC (n 25).

complaint stemming from these EEG discounts for industries, however, is that a disproportionate burden is allocated to residential consumers; according to the EC, "the EEG levy could be diminished by €ct 1.35, if all exemptions for German companies were revoked."[32]

Of particular note is the impact of the EEG on low income households. According to the EC, "in 2011, households spent on average 2.34% of their consumption expenditure on electricity. This share increased to 2.5% in 2013. For the lowest income group this share is significantly higher at 4.55% in 2013. However, the EEG levy accounts for 0.5%."[33] All sides agree that the impact of the EEG on low income households is a serious issue. *Energiewende*'s supporters, however, note that, according to IEA, "energy poverty is equally driven by the steep increase in fossil fuel costs," as many of the non-EEG electricity tariffs support fossil fuel generation.[34] In addition, when compared to some of the most developed countries in the world, such as the United States, energy poverty is less prevalent in Germany.[35]

While short run costs are substantial, *Energiewende*'s proponents find it is appropriate to frame them in relative terms. First, Germany's annual investment in fossil fuels has been €90 billion; and, unlike investments in *Energiewende* that primarily support electric grid upgrades, a large amount of fossil fuel investment manifests as one-off payments for fuel to foreign countries.[36] According to BMWi, "In 2013 Germany imported fossil energy sources to the tune of 92 billion euros. At the same time, around 9 billion euros in fuel costs were avoided thanks to renewable energy sources alone."[37] Second, there are signs EEG surcharge costs have hit a plateau; according to the BMWi, "For the first time since the Renewable Energy Sources Act (EEG) was introduced in 2000, the amount to be reallocated via the surcharge levied on electricity prices is to drop compared to the previous year... In 2015, the surcharge will be 6.17 ct/kWh."[38] And, also according to BMWi, the 2014 EEG amendment aimed to "slow any further rise in costs."[39] Third, according to the EC, "the share of payments for electricity compared to nominal GDP was 2.5% in 2011 (as well as in 2009 and 2010) which is the same level as in 1991."[40]

Another consideration supporters voice is the benefits that have arisen from past spending on *Energiewende*. Research from BMWi and BMUB suggests that investments in *Energiewende* have led to Germany establishing a 14% market share – second behind China – of the global green technology sector; a sector appraised at €2.5 trillion in 2014 and projected to double to €5.3 trillion by 2025. According to BMUB, "between 2013 and 2025, the domestic green tech market is expected to rise from EUR 344 billion to a volume of EUR 740 billion... In 2013, green tech accounted for 13 percent of Germany's gross domestic product."[41] To this tune, according to BMWi, "Germany has been one of the biggest exporters of technology and equipment for use in exploiting renewable energy sources. The value of exports just recently totalled around 10 billion euros."[42] BMUB estimates that these exports will increase to €47–69 billion by 2030. Projected net macroeconomic profit ranges from having committed to *Energiewende*, relative a business as usual (BAU) scenario, for 2020 and 2030 are €28 billion-€42 billion and €43 billion-€60 billion, respectively.[43]

In addition, *Energiewende*'s positive and pervasive employment impact is difficult to refute. In 2004,

32 Ibid.

33 Ibid.

34 IEA (n 21).

35 Andreas Fußer and Regine Günther, 'Electricity prices and grid infrastructure myths and facts about the role of renewable energies in Germany's 'Energy Transition'' (World Wildlife Fund, September 2012) <http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Myths_and_facts_about_Germany_s_energy_transition.pdf> accessed 15.01.2015.

36 Paul Hockenos, 'The Battle over Electricity: Part II' (German Council on Foreign Relations, 24 April 2013) <https://ip-journal.dgap.org/en/blog/going-renewable/battle-over-electricity-part-ii> accessed 15.01.2015.

37 BMWi (n 1).

38 Ibid.

39 Federal Ministry for Economic Affairs and Energy, '2014 Renewable Energy Sources Act: Plannable. Affordable. Efficient.' (Germany.info, 2015) <http://www.bmwi.de/EN/Topics/Energy/Renewable-Energy/2014-renewable-energy-sources-act.html> accessed 18.03.2015.

40 EC (n 25).

41 Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 'GreenTech made in Germany 4.0' (Germany.info, July 2014) <http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Broschueren/greentech_atlas_4_0_en_bf.pdf> accessed 18.03.2015.

42 BMWi (n 1).

43 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), 'Renewably employed!' (germany.info, September 2010) <http://germany.info/contentblob/3179136/Daten/1346894/BMU_RenewablyEmployed_DD.pdf> accessed 15.01.2015.

Germany's renewable energy sector employed 160,500 people, and that number doubled to 363,100 by 2013. Furthermore, 2013 employment directly attributable to the EEG was 261,500, 70% of total employment from renewables.[44] The net employment gain from renewable energy in 2009 alone was 70,000-90,000, compared to a BAU scenario. And this trend is only expected to continue. The projected net employment gains for 2020 and 2030 are 23,000-117,000 and 105,000-241,000, respectively. Furthermore, all regions of Germany are set to benefit from renewable energy expansion.[45] These benefits extend to the most remote regions of the country; as of 2013, farmers and individuals owned renewable energy investments amounting to over €100 billion.[46]

Transitioning to a microeconomic frame, supporters of *Energiewende* find the improving cost competitiveness of renewables encouraging. At present, premier wind farms produce electricity at a price comparable to that of gas and coal plants. In addition, the levelized cost of energy for solar PV has fallen 78 percent over the past five years, and PV is now competitive with residential electricity tariffs in many countries, including Germany.[47] By contrast, Germany's costs of importing oil, gas, and hard coal have increased by factors of 2.77, 2.68, and 2.26, respectively, over the past ten years.[48] While the costs of transitioning to an electricity grid based on renewables are high, revamping infrastructure now to support fuels with downward price trends and replace fuels with upward price trends could prove to have been a savvy investment.

IV. Reliability & Grid Optimization

The System Average Interruption Duration Index (SAIDI) measures the average interruption time per electricity customer, and it is the foremost metric used internationally for assessing electric grid reliability. This past August, Germany's Network Agency announced that the country's SAIDI value improved from 15.91 minutes in 2012 to 15.32 minutes in 2013.[49] This improvement is especially impressive considering Germany's 2012 SAIDI score was the third best in Europe[50] and less than a tenth of 244, the most recent statistic from the United States.[51]

Germany's impressive SAIDI validates BMWi's claim that, even after installing 70GW of intermittent wind and solar[52] and sporting a 2013 electricity generation mix with 25.3% renewables, "electricity supply in Germany is one of the most reliable in the world."[53] While Germany's SAIDI score paints a rosy picture regarding the country's past performance, it lacks nuance when assessing renewable energy's impact on infrastructure and other grid features that could impact future reliability.

A major reliability-oriented concern is the spike in grid congestion – both domestically and for neighbours – attributable to Germany's increased renewables generation. According to the EC, "most urgently, lines from the North to the South of Germany are needed to eliminate internal bottlenecks and help avoid unscheduled 'loop flows' which are currently congesting the borders with Germany's neighbours."[54] According to IEA, "these loop flows occur

44 Federal Ministry for Economic Affairs and Energy, 'Gross employment from renewable energy in Germany in 2013' (Germany.info, May 2014) <http://www.bmwi.de/English/Redaktion/Pdf/bericht-zur-bruttobeschaeftigung-durch-erneuerbare-energien-jahr-2013,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf> accessed 18.03.2015.

45 BMU (n 44).

46 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 'Transforming our energy system' (FES Japan, May 2012) <http://www.fes-japan.org/wp-content/uploads/2013/04/broschuere_energiewende_en_bf.pdf> accessed 15.01.2015.

47 Lazard, 'Lazard's Levelized Cost of Energy Analysis – Version 8.0' (Lazard, September 2014) <http://www.lazard.com/PDF/Levelized%20Cost%20of%20Energy%20-%20Version%208.0.pdf> accessed 15.01.2015.

48 Fußer and Günther (n 36).

49 Craig Morris, 'German grid more stable in 2013' (The Heinrich Böll Foundation, 25 August 2014) <http://energytransition.de/2014/08/german-grid-more-stable-in-2013/> accessed 15.01.2015.

50 Council of European Energy Regulators, 'CEER Benchmarking Report 5.1 on the Continuity of Electricity Supply' (CEER, 11 February 2014) <http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C13-EQS-57-03_BR5.1_19-Dec-2013_updated-Feb-2014.pdf> accessed 15.01.2015.

51 Roy L. Hales, 'Germany's Grid is One of the World's Most Reliable' (CleanTechnica, 11 August 2014) <http://cleantechnica.com/2014/08/11/germanys-grid-is-one-of-worlds-most-reliable/> accessed 15.01.2015.

52 Bloomberg New Energy Finance, 'Country Profiles: Germany' (BNEF, March 2015) <https://www.bnef.com/core/country-profiles/deu> accessed 18.03.2015.

53 BMWi (n 24).

54 European Commission, '2014 Country Reports: Germany' (Germany.info) <http://ec.europa.eu/energy/sites/ener/files/documents/2014_countryreports_germany.pdf> accessed 18.03.2015.

when Germany has insufficient grid infrastructure to handle power production... and the power is diverted through neighbouring countries' grids."[55] Poland and the Czech Republic are Germany's neighbours most negatively impacted by these 'loop flows.' In the Czech Republic, "transmission capacity is reduced because of loop flows originating mostly from Germany." [56] For Poland, "at times, no transmission capacity is available to the market because of significant transmission reliability margin (TRM) problems resulting from, inter alia, substantial loop flows from Germany."[57]

While the four TSO's have invested €1.15 billion on expanding high-voltage electricity networks that might mitigate grid congestion and resulting loop flows, "the expansion of the electricity transmission network has been advancing slower than planned. By July 2014, about 416 of 1,877 kilometers (22%) of the projects listed since 2009 in the Electricity Grid Expansion Act (EnLAG) were realised."[58] Furthermore, while, in 2012, BNetzA approved 2,800 km of new lines and 2,900 of network enhancement beyond EnLAG, the EC finds it "becomes increasingly doubtful in view of delays, whether the actual speed of network infrastructure construction is sufficient."[59]

Beyond the need for improved transmission and distribution infrastructure, the influx of intermittent renewables online in Germany has and will continue to require robust backup capabilities, especially during winter months. For the 2012-2013 winter, BNetzA contracted 2.6MW of reserve capacity and compensated these reserve plants for being prepared to generate power if needed. Despite this protocol, however,

> "In respect of the national balance between demand and supply, ENTSO-E calculated a negative reserve margin of -0.6% for Germany for the winter of 2012/2013 which indicates the national demand of electricity could be higher than generation capabilities. Germany may therefore need to rely on imports in certain situations."[60]

In addition to reliance on imports, Eurelectric emphasizes that,

> "In power systems that face growing intermittency, there will be growing demand for flexibility services... Additional flexibility services for system operators, related to smart grid, have to be developed. All different sources of flexibility, such as generation (including storage) [and] demand response... should be considered."[61]

Three flexibility mechanisms highlighted in this quotation are demand response (DR), smart grid enhancement, and storage. While DR has its critics and development is nascent in much of Europe, including in Germany, Eurelectric advocates for DR as "one of the building blocks of future wholesale and retail markets."[62] Germany has programs in place, such as the Ordinance on Agreements on Interruptible Loads – which is "designed to increase system stability by enabling system operators to remove industrial loads from the grid flexibly in critical situations" – that support DR.[63]

Smart grid enhancement is a second grid optimization measure on which Germany has lagged. However, short term forecasts from BNEF are optimistic. By 2018, 6 million smart meters are predicted to be installed, up from 1 million in 2014.[64]

Similar to smart grid infrastructure and DR, little energy storage capacity has accumulated; from 2000 through 2013, storage capacity in Germany grew from 301MW to 303MW, according to BNEF.[65] According to BMWi, however, "the German government is pushing research and development for storage technologies forward and has made 200 million euros available for the 'Energy Storage Funding Initiative'."[66]

While flexibility mechanisms and imported power function as reliability enhancers, few dispute the

55 IEA (n 21).

56 Ibid.

57 Ibid.

58 EC (n 55).

59 Ibid.

60 Ibid.

61 Eurelectric, 'Renewable Energy and Security of Supply: Finding Market Solutions' (Electricity for Europe, October 2014) <http://www.eurelectric.org/media/154655/res_report_140919_lr-2014-030-0569-01-e.pdf> accessed 18.03.2015.

62 Ibid.

63 BMWi (n 24).

64 Bloomberg New Energy Finance, 'Market Size: Smart Meters' (BNEF, 2015) <https://www.bnef.com/MarketSizing/Smart-Meters#si-222~sb-2~df-2008~dt-2018~fa-1~vd-0~sp-0~st-1~fy-1~ct-0~sw-0~dp-0> accessed 18.03.2015.

65 Bloomberg New Energy Finance, 'Market Size: Energy Storage' (BNEF, 2015) <https://www.bnef.com/MarketSizing/EnergyStorage/MW#si-222~sb-14~df-2000~dt-2013~vd-0~sp-0~st-1~fy-1~ct-0~sw-0~dp-1> accessed 18.03.2015.

66 BMWi (n 24).

integral role fossil fuels have played – and promise to continue to play – as a critical source of backup power for ensuring grid reliability. According to IEA, "conventional power plants are still needed, also in the long-run (~50GW with 80% RES)."[67] What's potentially problematic for grid reliability is that the influx of renewables in the generation mix is hurting the profitability of these essential fossil fuel generators in three ways. First, these plants are tapped far less frequently than in the past. Second, lower wholesale prices due to the increase of renewables, whose operating costs are negligible, "further discourage firm capacity providers from remaining active."[68] Third, according to Eurelectric, "greater RES intermittency on the supply side coupled with greater demand participation, energy efficiency, and macroeconomic impacts on the demand side are making market outcomes increasingly difficult to predict."[69]

To this point, the Heinrich Böll Foundation asserts that "even the strongest proponents of Energiewende agree that Germany needs to reform its energy system to accommodate the next influx of renewable energies."[70] As a potential solution, Heinrich Böll and others, such as Eurelectric, advocate a shift away from the "energy-only" market – in which utilities are only paid to produce and deliver energy – to one that is more profitable for utilities as renewables take over the generation mix. The German government is confident in its short term grid reliability, and IEA seconds this notion asserting that "Germany has time to adjust its energy-only market design; it runs a sufficiently high reserve margin and is well interconnected with neighbouring countries."[71] Hence, the German government is carefully – prioritizing a sound decision over a quick one – approaching potentially reforming the structure of its electricity market in a way that ensures reliability through fair compensation for backup power providers.[72]

In addition to needing a more flexible grid and an electricity market that more fairly compensates backup power providers, in order to ensure reliability, grid operators must be prepared to manage more grid intervention events, which could lead to blackouts, as renewables gain market share. From 2010 to 2012, grid intervention events increased fourfold in Germany.[73] As evidenced by Germany's strong and improving SAIDI score, grid intervention events have yet to significantly impact the country's reliability of electricity supply. However, grid intervention events promise to become more prevalent and require more management effort as renewables capacity grows.

Lastly, an environmentally framed criticism of how Germany ensures grid reliability centres on coal's sizable share of Germany's generation mix. According to the EC,

> "In the short term, the shutdown of the nuclear power plants is likely to result in a higher use of gas and coal... The share of coal in the energy mix has increased by 1 percentage point between 2008 and 2012... Recent energy trade data show that imports of coal have increased significantly in Germany (+37% between 2011 and 2012)."[74]

Furthermore, while many sources, including the EC and IEA, are not bullish towards coal's long term prospects in Germany, IEA highlights that the construction of some coal plants in Germany in recent years will ensure a role for coal "as a cornerstone of Germany's electricity production well into the medium term."[75]

The German government, to its credit, has acknowledged that the country has "too much coal in the grid" and has been proactive in steering its electricity sector in a direction that minimizes coal usage. In March 2015, Germany advocated for a 'very quick' reform to the EU emissions trading system that would benefit power plants fired with natural gas over coal.[76] Furthermore, IEA and others predict

67 Dittmar (n 2).

68 Eurelectric (n 62).

69 Ibid.

70 Rebecca Bertram, 'Capacity Energy Markets: A view from Germany and the United States' (The Heinrich Böll Foundation, September 2013) <http://sallan.org/pdf-docs/Germany_CapacityEnergyMarkets.pdf> accessed 15.01.2015.

71 IEA (n 21).

72 BMWi (n 1).

73 Institute for Energy Research, 'Germany Electricity Market Out of Balance' (Canada Free Press, 22 August 2014) <http://canadafreepress.com/index.php/article/65495> accessed 15.01.2015.

74 European Commission, 'European Economy' (EC, June 2014) <http://ec.europa.eu/economy_finance/publications/occasional_paper/2014/pdf/ocp196_en.pdf> accessed 18.03.2015.

75 IEA (n 21).

76 Bloomberg New Energy Finance, 'Germany Seeks 'Very Quick' EU CO2 Market Reform to Cut Coal' (BNEF, March 2015) <https://www.bnef.com/core/news/97329> accessed 18.03.2015.

the decommissioning of "substantial volumes" of coal-fired capacity due to the phase out of hard coal subsidies by 2018 coupled with the implementation of the EU Large Combustion Plant Directive and the fact that just under 60% of coal capacity was commissioned between 1970 and 1990. [77] To this tune, Poyry (2013) concludes that "there will be no major new unabated coal or lignite projects in Germany for the foreseeable future beyond those currently under construction."[78]

V. Conclusion

The German example is rife with lessons – pertaining to politics, governance, economics, grid reliability, and grid optimization – for other countries, such as the United States, to internalize as intermittent renewables become more prevalent in their generation mixes.

Proponents of an energy transition in the United States face a tall order politically. Four American-based oil companies (Exxon, Chevron, Phillips 66, and Valero) and two motor vehicles companies (General Motors and Ford) are members of *Fortune*'s top 10 companies.[79] Powerful people have depended on fossil fuels for making their fortunes, and the Koch brothers and other fossil fuel magnates are not shy about financing political campaigns. Such an old guard is also prevalent in Germany, so studying how German renewables integration advocacy efforts have succeeded in building and maintaining popular support via emphases on consistent, transparent communication with the public, as well as cost minimization, is fruitful for those in favour of an energy transition in the United States.

Related to politics, *Energiewende's* dynamic development illustrates the importance of continued flexibility in governance structure for energy transitions. Inherent to a 'mammoth' policy initiative with political, social, and economic relevance, overlapping responsibilities of federal ministries must be minimized as an energy transition evolves and the various levels of government (local, state, federal, etc.) must work together to optimize the country's strategic integration of renewables. This flexibility must extend to governance structures that enable countries to rework policies used for achieving renewables targets, but that do *not* make it easy for politicians to weaken targets. A key to an energy transition's success is how it develops within the political agendas of fluctuating heads of state, some of whom might oppose the energy transition in future years.

The German example provides both encouraging and cautionary lessons regarding the economic and grid reliability impacts of proactive renewables integration. Regarding economics, macroeconomic costs of *Energiewende* have placed substantial burdens both on energy-intensive industries, whose shares of their respective global markets are at risk due to high power prices, and on residential consumers, especially those from low-income households, who bear a disproportionate share of *Energiewende*'s costs. Associating as an *Energiewende* proponent requires belief that macroeconomics benefits – via large employment gains and the establishment of significant market share in an already large industry that's poised to boom – as well as microeconomic indicators, such as rapidly declining prices for renewables, justify such high short-term costs.

Regarding reliability, the German example shows that a grid that derives over a quarter of its power from renewables can become a global leader in supply security – in terms of SAIDI – given ample reserve capacities and well-developed interconnections with neighbouring grids. However, extensive and expensive transmission and distribution (T&D) infrastructure must be built to prevent renewables-induced grid congestion that damages both T&D infrastructure and threatens grid reliability both domestically and for neighbours. In addition, what is essential for long term reliability for a power system in which renewables comprise a large share is an electricity market structured in a way that fairly compensates backup power providers. Also desirable for a reliable grid are well-developed flexibility tools, such as demand response, smart grids, and energy storage.

Energiewende is entering the fifth year of what is intended as a forty year undertaking. As it evolves,

77 IEA (n 21).

78 Department of Energy & Climate Change (DECC), 'Poyry report to DECC: Outlook for new coal-fired power stations in Germany, the Netherlands, and Spain' (gov.uk, 7 May 2013) <https://www.gov.uk/government/publications/poyry-report-to-decc-outlook-for-new-coal-fired-power-stations-in-germany-the-netherlands-and-spain> accessed 15.01.2015.

79 Fortune, 'Fortune 500 2014' (fortune.com, 2014) <http://fortune.com/fortune500/wal-mart-stores-inc-1/> accessed 15.01.2015.

lessons will continue to manifest. The German Institute for International and Security Affairs argues, "If the [German] energy transition succeeds, it will serve as an international model."[80] Germany has gifted the world an example of an energy transition. It is the rest of the world's prerogative to learn from the German example.

80 Westphal (n 10).