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Coal, nuclear and renewable energy policies in Germany: From the 1950s to the "Energiewende".

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Abstract

Over the last 50 years, German energy policy has ranged from strong enthusiasm for both coal and nuclear energy to deep skepticism. The most dramatic changes with respect to energy policies have occurred as a response to nuclear accidents, yet the accidental and unintended effects of coal policies are also important in influencing the trajectory. The newly emerging climate debate prevented the coal industry from acting as a substitute for the diminishing share of nuclear power. In 2011 the conservative government announced the *Energiewende* ('energy transformation') and decided to reduce the amount of fossil fuels from 80% of the energy supply to 20% by 2050. However, while the verdict on nuclear was unequivocal with a final phase-out date of 2022, the share of coal in the electricity market did not decrease and the amount of carbon dioxide released into the air slightly increased from 2011 to 2013. There

are growing conflicts over the immediate costs and practicalities of coal replacement. Consequently, the future of coal in Germany is still relatively open and contested.

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1. Introduction

The promises of an allegedly cheap, clean and inexhaustible renewable energy supply contrasts strongly with the concerns about pollution and climate change arising from burning fossil fuels, and the safety, weapons proliferation and waste disposal issues arising from nuclear power (Martinez and Byrne, 1996). Yet implementing policy in favor of renewables has not been straightforward in Germany. Major influences in the history of German energy policies have, on the nuclear side, included the incident at Three Mile Island in the United States, the Chernobyl accident in Ukraine and, most recently, the nuclear meltdown at Fukushima in Japan. On the coal side, disenchantment with coal started in 1960s with concerns about the health effects of particulate pollution. In response, the technical elite emphasized the possibilities of making coal cleaner, and a high stack policy was introduced to dilute pollutants. However, high-stacks were subsequently blamed for amplifying the "Waldsterben", or the slow dieback of German forests, through spreading nitrate emissions into the upper atmosphere and creating acid rain (Kenk and Fisher, 1988). Opposition to coal intensified with knowledge of climate change in the '90s and beyond. Consequently, the dominant narratives of coal as a solid domestic energy source and of nuclear as an inexpensive, and environmentally friendly powerhouse faced skepticism and open protest.

Change in narratives triggered major changes and adjustments in public attitudes as well as in regulation and risk management (WEC, 2012).

This paper gives a brief history of these policy complexities in the electricity market, in which coal and nuclear have made up more than 85% of Germany's electricity generation (in MWh). We describe the responses of regulators and policy makers to contingent events, public opinion, economic pressures, and political commitments. Some abrupt policy changes resulted from actors taking unexpected strategic opportunities, as when anti-nuclear campaigners used the public outrage after Chernobyl and Fukushima to press forward new policy initiatives. Policy was always conducted in complex, uncertain and unpredictable fields (social and ecological) producing results that were neither foreseen nor intended by the dominant actors, undermining intentions, or leading in new directions. Policy making with respect to the environment, is not simply an *a priori* rational or predictable process, aiming to cater to divergent interests; it also seems self-disrupting and paradoxical.

2. The European Context of Energy Policies

Before discussing energy policies in Germany it is important to understand the European context. Energy policy is at the heart of the European political and economic integration process (Matlary, 1997). The strong influence of the European context is illustrated by three major policy developments: (i) deregulation and liberalization of European energy markets; (ii) climate change; and (iii) energy security.

2.1 *Deregulation and liberalization of energy markets in Europe*

In the mid-1980s, a consensus on economic policies emerged among European business and policy elites, which assumed that 'deregulated' and liberalized markets improved economic efficiency. This conviction initially shaped policies in Great Britain, but was later adopted by

all European leaders in the guise of EU internal market policies. It almost certainly increased disruptive corporate influence on EU Energy Policy as the energy industry aims at profit before attending to energy security, low costs or sustainability.

Previously, energy markets in Europe were relatively heavily regulated, with public monopolies dominating. Hence, the new paradigm was a significant challenge to energy policy-makers and faced resistance from the old providers. Despite resistance, the markets were gradually liberalized and public monopolies challenged.

The principles of liberalization were not applied universally, or coherently, to all energy sources. This was particularly true for nuclear power, which was often offered protection from market competition through subsidies and other interventions, as its ability to raise capital from private investors was limited due to the uncertainty associated with large up-front investment costs, insurance costs, and uncertainty about licensing over its life span (Hatch, 1986).

2.2 *Climate Change – European, national and international targets*

Climate change has increasingly gained salience for policy-makers and in the public mind. Energy policy is a crucial means of influencing climate change as the mix of energy sources determines emission levels of greenhouse gases (GHG) (in particular, CO2) which generate such change. The climate change debate proved a major challenge to the acceptability of coal and fossil fuels generally, and thus challenged corporate profits in the liberalized energy market. Many players in the relevant corporate sector responded through ideological obfuscation, with market 'necessities' often corrupting the flow of accurate profit confronting information, and in turn confusing policy processes (Beuermann and Jaeger, 1996).

Despite the confusion, measures to curb CO2 emissions were undertaken on the international, European and national levels. The Kyoto protocol to the United Nations Framework on Climate Change, adopted in 1997, called for Greenhouse Gas emissions to be reduced by 2008-2012 with European Union countries accepting the obligation to reduce their GHG emissions by 8% from those of 1990. Some European countries, among them the UK, Germany and France, established more ambitious national targets, others such as Poland and Czechoslovakia favored continuing coal use. Germany decided to reduce fossil fuel use by an astonishing 80% by 2050 (Lauber and Jacobsson, 2015).

A variety of policy measures were established to achieve these targets, ranging from EU (and additional national) emission certificate trading schemes (which did not work that well, see Bryant this issue) to energy conservation incentives and climate change levies. The nuclear industry expected to benefit from these climate commitments as it is virtually carbon-emission free, after the plant is constructed. However, after the Fukushima accident, Austria, Switzerland, Italy, Denmark and particularly Germany, shifted their climate policies further towards renewable energy, whereas France and the UK reasserted their commitment to nuclear power as a tool for reducing climate change.

2.3 *Energy security- the revival of a well-known concern*

Oil price hikes, unstable (or possibly hostile) political regimes in the Middle East and Russia, and depletion of North Sea oil and gas fields, fed into growing concerns over the political and economic vulnerability of Europe to energy insecurity. These policy concerns seem to have diminished with the exploitation of more domestic oil and gas reserves through fracking technologies, despite people in many European countries (especially Germany) having strong environmental reservations against fracking, and despite more than 60% of the fossil fuels consumed in Germany and more than 80% consumed in France still being imported

(Schirrmeister, 2014). The imagined prospect of having more fossil reserves than previously assumed seems to have reduced fears over dependency. However, energy security remains a major topic of debate in Germany and other European nations (McCollum et al., 2014; Kleinert, 2011) and has strengthened the position of indigenous energy sources such as coal, nuclear power and renewables.

3. The German National Energy Context

3.1 *The energy situation in Germany*

Germany is the largest energy market in Europe. Energy supply fell in the 1990s, partly due to restructuring the economy of the former German Democratic Republic, (the so-called New Länder states), the decommissioning of some inefficient and polluting New Länder power stations, and the privatization of utilities and lignite mines. Between 2000 and 2010 the demand for electricity and gasoline (traffic) increased, while the demand for primary energy sources for producing heat (low and high temperature) significantly decreased (AG Energiebilanzen, 2015). The latter is partially due to governmental subsidies for energy efficient renovations in industry and private households, and the abandonment of coal burning for household heat.

Until 2010, half of all domestically produced energy came from coal and lignite; the rest came from nuclear, gas and renewables. Since 2010 the share of renewables has dramatically increased while the share of nuclear has decreased in the same period (Renn, and Dreyer, 2013; AG Energiebilanzen, 2015b). Coal and lignite production has remained almost static over the last decade. The share of nuclear energy in domestic energy production, currently at 14%, is likely to reach zero by 2022 if the phase-out decision is not reversed or modified. Domestic gas production accounts for less than 10% in 2015 of the overall electricity

production, whilst domestic oil production was negligible compared to demand (AG Energiebilanzen, 2015b).

Despite efforts to improve energy security through domestic production, energy imports still account for 60% of total primary energy supply. The former Soviet Union is the largest energy supplier (almost 30%), followed by the Netherlands (17%) and Norway (16%). Less than one-tenth of electricity is obtained from sources abroad, with imports and exports almost offsetting each other (AG Energiebilanzen, 2014: 11)

3.2 *Energy industry*

The German oil industry became fully privatized as refineries and distribution companies in the New Länder were handed over to private companies in 1992. The German oil market had a large number of players, although liberalization has coincided with major mergers in recent years (e.g. Exxon and Mobil, Total, PetroFina and Elf, the merger of BP and Veba Oil and Deutsche Shell and DEA Mineralöl), possibly producing less intense competition.

The German coal producing sector is still the largest in Europe despite only one company producing hard coal in Germany, the RAG AG. This dominance was achieved when RAG took over Saarbergwerke AG (previously government-owned) and Preussag Anthrazit Gmbh (previously owned by Preussag AG). The RAG subsidiary, Deutsche Steinkohle AG, is responsible for RAG's German hard coal operations. The lignite mining sector is dominated by Braunkohle AG, a subsidiary of one of the largest electricity producers, RWE. Liberalization can lead to monopolization, not the expected competition.

The German gas sector is also the largest in Europe. In contrast, it is highly complex and competitive. It can be described as a multi-tiered, decentralized structure with a number of

privately and municipally owned gas utilities. By 2002, there were 16 natural gas producers, 14 supra-regional companies six of which also imported gas (Ruhrgas, RWE, Wingas, BEB, EWE and VNG), 15 regional distribution companies and more than 700 local distributors and 11 gas dealers. This has not changed significantly over the last decade. Ownership of the companies was diverse, from municipally owned local distributors to the large privately-owned supra-regional companies, with foreign companies holding significant shares (IEA, 2012: 18)

The German electricity sector is structured similarly to the gas sector. By 2014, there were 4 supra-regional companies, 56 regional utilities, more than 800 local utilities and about 120 electricity dealers. Supra-regional companies generate electricity (80% of the market), transmit it over regional boundaries and supply electricity to the final consumer. The four companies (RWE, EnBW, E.ON and Vattenfall Europe AG) resulted from mergers: RWE acquired VEW Energie AG in 2000; VIAG and VIBA merged in 2000 to form E.ON; The Swedish company, Vattenfall, acquired majority ownership in VEAG, HEW and BEWAG. However, with the Energiewende, the number of prosumers (generating solar energy for consumption and selling the surplus to the national grid) has risen to more than 40,000, thus changing the energy supply sector dramatically. About a third of self-generated solar power is fed into the national grid, while another third is self-consumed by the home or business (Meza, 2013). This change results from price guarantees based on the EEG (Renewable Energies Act) and local action not liberalization.

4. Electric Power Regulation and Policy Making

4.1 *Overview*

Germany's political system is shaped by federalism. Consequently, Federal and state governments are involved in policy-making. All energy legislation is planned and adopted at

Federal level, but state-level governments are responsible for implementing federal laws (Hatch, 1986). In addition, state-level governments can develop their own programs such as promoting renewables.

On the Federal level, the main responsibility for energy policy and research and development lies with the Federal Ministry of Economics and Technology (BMWi). The Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU) is in charge of environmental policies, including climate change, nuclear safety and the impacts of fossil fuel combustion. Promotion of energy conservation and efficiency is undertaken by the German Energy Agency (DENA), created in 2000. The regulation of competition in energy and electricity markets is the responsibility of the Federal Cartel Office (FCO) and, in some more local and regional cases, the state-level competition offices. Furthermore, energy policy is often guided by reports and discussions conducted by independent expert panels and institutes. One of the most important open discussion platforms shaping the energy policy of the previous government, was the Energy Dialogue 2000, led by Federal Ministry of Economics and Technology and the Forum for Future Energies, with the participation of political parties, state-level governments, companies, organized labor, and environmental organizations. This platform recommended the phase-out of nuclear energy and the slow termination of fossil fuels. Energy forecast reports are regularly undertaken by independent research institutes. After Fukushima, the ad hoc Commission on the Future of Energy Policies (the so-called Ethics Committee) provided the main direction and justification for both the accelerated phase-out of nuclear energy and the roadmap for an energy supply system dominated by renewable energy sources (Ethik Kommitee, 2011). This combination of nuclear phase-out and reduction of fossil fuels were the two major components of the German Energiewende. The third element was the dramatic increase in projected energy efficiency.

Recommendations by the Ethics Committee included a phase-out of coal from the power market by the end of the century with an 80% reduction by 2050.

Environmental policies, related to the energy sector, are led by the Federal Ministry for the Environment, Nature Protection and Reactor Safety (BMU). However, policy measures are also undertaken at local and state-level. In addition, special committees have been set up such as the Committee for Sustainable Development in 2001 and the Council of Sustainable Development (comprising representatives of all relevant interest groups in the area of energy and climate change policy). The latter developed a National Strategy for Sustainable Development that was adopted by the government in April 2002. Even the nuclear industry did not openly oppose the verdict, although challenged the "ambitious" time plan and asked for help sustaining nuclear expertise in dealing with continuous tasks such as waste processing and depositing, decommissioning of nuclear power plants and participation in international safety and security research.

Energy efficiency policies are at the core of activities undertaken by DENA since 2000. The DENA was established by the government and the German reconstruction bank, Kreditanstalt für Wiederaufbau (KfW) in order to bring together the various players in the energy sector, help implement energy efficiency policy and promote renewable energy sources, climate change mitigation and sustainable development.

4.2 *Energy policy development before 1986*

Germany's energy policy between 1945 and 1973 was characterized by a relatively low degree of state interventionism and a broad acceptance of both nuclear and coal as energy sources. In the first decades after the war, German energy policy was essentially coal policy due to the economic and political power of the coal industry(Hatch, 1986). In 1950, coal

accounted for almost 90% of Germany's primary energy consumption. More than half a million people were employed in the coal industry throughout the 1950s. Most of the industry was located in the Ruhr basin in North Rhine-Westphalia, one of the economically and politically most powerful of the eleven Länder in the Federal Republic. Coal mining workers were organized in a powerful and influential trade union, I.G. Bergbau und Chemie, which was closely affiliated with the Social Democratic Party. Coal was an unchallenged champion.

Nuclear energy started to become important in the late 1950s. Pro-nuclear interests found a favorable partner in the specially established Ministry of Atomic Affairs, which under the social-liberal coalition became the Ministry of Research and Technology. In 1967, the first commercial orders were placed for two light water reactors (LWR) by German utilities; two years later, three more were ordered; and in 1971, five more orders were placed. By 1973, all ten projects had permits to begin construction, with additional plants planned for the near future. The two companies, Siemens and AEG, with licenses for light water reactors by Westinghouse and GE respectively, took the leadership in the plant construction industry, although AEG gave up nuclear power construction in the 1970s. The companies were encouraged by the government to establish the joint reactor development company Kraftwerk Union (KWU). When AEG discontinued its nuclear ambitions. KWU became a subsidiary of Siemens only.

In addition, Germany supported the development of a Thorium High Temperature reactor (THTR), but support ended in the early 1980s as no commercial company was willing to build them. The government was also involved in developing a reprocessing plant to close the nuclear fuel cycle. Basically, despite governmental support, nuclear energy experienced uncertainty even in the early days and, as we shall see, there was considerable opposition to it.

The oil crisis in 1973/1974 fundamentally transformed energy policy in Germany from relatively limited interventions to protect coal companies and their employees, into a comprehensive policy aimed at securing low-cost energy supply, while respecting environmental protection. This shift was reflected in the 1973 Federal energy program, which was revised in 1974 as a result of cutbacks in oil supply by Arabic countries, in the so-called Oil Crisis.

Some years later, energy conservation was given formal priority with the second revision of the energy program in 1977. Despite disputes over the provision of funding (between state-level and Federal level), as well as the type of measures (regulation vs. market incentives), a major package was agreed in 1979 and confirmed in a third revision of the energy program in 1981. By the time of this revision, coal was seen as a domestic resource and seven new coal fired power stations were commissioned. In addition, almost a dozen nuclear power plants were ordered, with others planned for construction later. In spite of major debates on nuclear safety, most elites in Germany supported the expansion of coal and nuclear as the best guarantees for energy security.

Simultaneously, in the 1970s, the environmental movement and public protest against nuclear power, became a strong political force, leading to the establishment of a new party, the Greens (Renn, 2008, p. 60). The environmental movement also targeted coal fired power stations and open pit mining but protests remained at a low intensity to avoid fighting on two fronts concurrently. The anti-coal coalition of the early 1970s was largely confined to the local level.

Major anti-nuclear power protests started in 1975 with ad hoc citizens' initiatives (the so-called Bürgerinitiativen) in the state Baden-Wurttemberg where a large plant (Wyhl) was

approved for construction. The initiatives gathered signatures of local citizens objecting to the construction of the plant and appealed to the administrative court. Arguments in these local campaigns initially revolved around local issues (Hatch, 1986). Later all sites for planned nuclear power plants became targets of major protest movements and demonstrations. Public outrage was specifically strong at the site of Brokdorf where demonstrators and police engaged in fierce battles.

The increasing relevance of nuclear energy and the increasing public opposition triggered a response by government, the so-called "Bürgerdialog Kernenergie", which aimed at regaining trust and promoting a propagandized consensus on nuclear energy. The engagement of the Federal government with the public took several forms (newspaper advertisements, information brochures, public discussions) and changed its content over time in response to the broad concerns of the public, from purely safety-related issues at the beginning to less contentious issues such as the desirability of technological progress. However, polarization remained and violent clashes between protesters and police propelled the debate into a national showdown between government and protesters. Governmental communication strategy had little impact, and may have brought the debate to wider public prominence.

Despite considerable success in mobilizing the public and putting nuclear energy on the national political agenda, the crucial battleground for German protesters were the courts. The courts dealt with nuclear issues from a wide range of perspectives not just energy policy: Whilst, for example, a construction stop for the plant in Wyhl was issued on the basis of safety concerns, the decision to stop construction of Brokdorf plant in the state of Schleswig-Holstein arose because of the unresolved problems of storage and disposal of radioactive waste. An administrative court in Lower Saxony accepted the arguments of a pharmaceutical company, which feared contamination of their medical products because of their close

proximity to the nuclear reactor. In another significant case, the prerogative of the state executive to grant a license for the construction of the FBR at Kalkar was questioned by the court in the light of security and waste storage issues.

By the end of 1977, work on three of the thirteen plants under construction was halted. In response, the industry pointed to the economic costs of reversal in terms of employment and technology export opportunities, two key issues in economic debates in Western Germany and two key factors justifying liberalization, even if nuclear energy needed state subsidies.

In spite of fierce demonstrations and the court cases that prevented the construction, or the operation, of several nuclear plants the protest movement had little success in halting nuclear polices or influencing the majority of German people to develop an anti-nuclear attitude. (Wagner, 1994). Until 1986, all parties except the Green party supported nuclear expansion. The early 1980s even witnessed a gradual improvement of the prospects for nuclear power, despite the ongoing political successes of protestors. In particular, the second oil crisis (with its skyrocketing prices) made it easier for the SPD-FDP government to renew their commitment to nuclear power in the third revision of the energy program in autumn 1981. Federal and state-level governments collaborated to speed up the licensing processes so that in February 1982, after a delay of five years, construction of three new power plants was authorized by the Interior Ministry in 'convoy'. The three permits were granted on the basis of an approved standardized design and a governmental assessment that the criteria for waste disposal were satisfied.

Under the shadow of the controversies about nuclear energy, the environmental debate on coal and its impacts had little resonance (Lauber and Jacobsson, 2015). In West-Germany, new open pit mines for Lignite coal were licensed in the mid-1980s despite local protests. The

climate change debate had only just started and the connection of climate protection with Germany's coal program was on the agenda of most environmental NGOs. They were reluctant to fight on both fronts: nuclear and coal. At the same time, coal was regarded as a domestic energy source that guaranteed energy security and stability on the labor market. So both nuclear and fossil fuels coexisted until 1986. This was the year when the nuclear industry experienced its greatest blow: Chernobyl.

4.3 *Energy policies after 1986*

The Chernobyl accident had a major impact on public opinion and triggered substantial policy changes by the federal government. The most obvious change was the establishment of the BMU, the federal ministry for environment, nature conservation and reactor safety. Before 1986, environmental issues were handled by the ministry of the interior. One of the first ministers appointed to head the BMU was Klaus Töpfer, who later became the director of UNEP, and after Fukushima was asked by Chancellor Merkel to chair the Ethics Committee on the Future of Energy Policies in Germany.

After Chernobyl, the Social democrats (SPD) adopted more critical positions towards nuclear energy, while emphasizing pro-coal policies as part of their energy security program. The workers in Germany's coal mines, who were mostly organized in unions, were traditionally Social Democratic Party voters. Similarly, the conservative Christian Democratic Party, was influenced by the coal lobby, (the steel industry, local coal communities and the unions), to sustain support for a national coal strategy. This strategy had two components. Firstly, coal subsidies for uneconomic hard coal mines were guaranteed in a National phase-out plan until 2018. The hard coal industry could continue operations until this date but was obliged to phase out mining operations (there are only two hard coal mines left in operation in 2016). Subsidies for hard coal mining amounted to 327 billion Euros from the Federal and State

Government between 1970 and 2014 (FÖS, 2105). (2) For economic, and energy security reasons, lignite was not included in the phase-out plan. Lignite was regarded a national reserve that should continue to be supported.

In the time period from 1986 to 1998 (during the Kohl administration) nuclear energy was severely attacked by the opposition parties, in particular the new green party, and the hard coal phase-out was launched, with lignite being established as a national reserve. Even before 1998 when the Social Democrats (SPD) took office on the federal level, nuclear policies were strongly affected by growing opposition from the SPD. The conflict between the governing conservative party (CDU) and the SPD led to the collapse of collaboration between states and the Federal government on the issuing of nuclear licenses. SPD-led states actively started to implement legislation consistent with the official SPD-policy of exiting nuclear power (Kern and Löffelsend, 2003). These state level attempts were bound to fail because the conservative and the liberal party with command over the federal government could sustain their pro-nuclear position on the federal level until 1998. Once facilities (plants and storage sites) were up and running, it proved difficult for state-level governments to shut them down. As long as plant operation was ‘orderly’, the Atomic Law protected them from closure. However, the new levels of conflict and inconsistencies between the rhetoric of the pro-nuclear advocates and the reality of nuclear power production, with many safety breaches and critical incidents, emphasized that nuclear energy was vulnerable.

During the 1990s, climate change became more salient to the long standing background debate on the negative impacts of mining and burning coal. However, the main problem for the traditional hard-coal mining industry was not environmental but economic. German coal was much more expensive than imports from Poland or Australia. The growing environmental concerns of NGOs and environmental activists added to a slow process of financial retreat

from coal but it was not the major motive for the industry to reduce coal mining activities in the Ruhr and the Saarbrücken districts, the two main areas in Germany with a tradition of hard-coal mining. Indeed, the engagement of social democrats and unions kept many coal mines alive to sustain employment (Lauber and Jacobsson, 2015). The so-called Left in Germany tended to incoherence on issues around climate change and lowering coal consumption.

Environmental concerns were also raised about lignite coal, which is far more polluting than hard-coal. In addition to more extensive land-use and destruction of agriculture, the average CO2 emission per Kilowatt hour amounts to 0.41 kg for lignite coal in Germany and to 0.34 kg for hard coal (Volker-Quaschning, 2015). Lignite is also heavier for other emissions, in particular nitrogen oxides. However, lignite was much more profitable as it could be produced in cheaper open pit mines. The lignite industry was able to expand its operation in western North-Rhine-Westphalia. New pit mines such as Hambach were initiated in the late 1970s and villagers were relocated in the early 1980s to provide room for more mining activities. There was local protest but little national attention as most environmental groups were still concentrating on fighting nuclear energy. Furthermore, the phase-out of hard coal was already highly controversial and the consensus emerged that Germany would at least need its lignite coal reserves to secure energy supply.

The unification in 1989 had a significant effect on the perception of coal. Germans were suddenly confronted with partially contaminated or devastated areas in the Eastern coal-mining districts (often close to areas with a high concentration of polluting chemical factories). Many landscapes looked like “moon structures”. While these impressions confirmed the image of coal as dirty they also encouraged many pro-coal activists, union members and politicians to demonstrate that ‘re-naturalization’ efforts could compensate for

the destruction in both ‘East’ and ‘West’. By re-naturalization, the West could show the East the benefits of capitalism. Re-naturalized landscapes, such as the area near Bonn in North-Rhine-Westphalia (Ville), became popular tourist sites with newly grown forests and artificial lakes. Similar efforts were undertaken in East Germany and more than 4 billion Euros were spent turning devastated landscapes into parks or recreational areas (not all very successfully). The intended message was clear: coal has its negative impacts but with modern technology, emission control and landscape re-engineering one could master these impacts. The debate was less about whether coal mining and coal-fired power production should be continued but rather in what form, and to what degree, and how the deleterious effects on countryside could be repaired.

This altered when a coalition of the SPD and Green Party won Federal power in 1998. After its inauguration, the new government emphasized sustainable development in its energy policy. Its three key principles were: (a) supply security, (b) economic efficiency and (c) environmental compatibility. The government identified several key areas of action: (i) the mitigation of climate change; (ii) promoting energy efficiency; (iii) continued use of domestic coal and lignite; (iv) creating more competition in the liberalized energy markets; (v) promoting renewable energies; and (vi) creating a level-playing field for energy companies throughout Europe. This program was complemented by the phasing-out of nuclear energy (IEA, 2007).

The incorporation of energy security into the catalogue of main objectives recognized the relatively high dependence of Germany on energy imports and the ongoing depletion of local fossil fuel reserves. The hope was that further market liberalization would ensure efficient usage of energy, diversify supply sources, and improve energy services and energy trade. The government entrusted decision-making on investment, new capacity and timing, to the energy

industry, to an extent surrendering its power, even while attempting to change energy policy. After 2011, this changed when the government launched the "Energiewende". The energy industry is now highly regulated in Germany, and constantly complains about it.

Initially, environmental compatibility was to be achieved through a mixture of voluntary agreements with the industry e.g. the 2000 "Agreement on Global Warming Prevention" (which was meant to reduce CO2 emissions per unit of output by 28% by 2005 and overall greenhouse gas emissions by 35% by 2005, when compared to 1998 levels), the eco-tax, the promotion of renewables (through the Renewable Energies Act, the Market Incentives Program and the 100,000 Rooftops Solar Electricity Program) and energy efficiency improvements. Overall the policy aimed at a continuous phase-out of nuclear energy, a reduction of fossil energy production and consumption, increase of energy conservation and an increase in renewable energy production, with the goal of curbing CO2 emissions by more than 20% by 2020 and more than 40 percent by 2030.

Both parties agreed that phasing out nuclear power was a top priority. However, the exact method of achievement invoked controversy between the coalition partners and within the Green Party itself. The SPD wanted to avoid any compensation claims by the utilities, hence, favored a phasing-out in consensus with the industry. The Green Party was split. The more pragmatic wing, primarily those who had been working in governments at state level, particularly in the Ministry of Environment in Hesse, knew about the legal and political difficulties of imposing a phase-out on electricity utilities. Hence, they were more sensitive to the problems of demanding an immediate shut-down of plants, an end to the shipment of nuclear waste by trucks (loaded with so called Castor casks in which spent nuclear fuel was stored) and the export of nuclear waste. As a result, they sought to explore the opportunity of a constitutionally sound, and compensation excluding, law that would lead to a gradual phase-

out of nuclear energy. The radical wing of the party, closely affiliated with anti-nuclear activists, wanted an immediate exit.

After a long debate, an agreement was reached in 2002 with the limits of operation, in general, fixed at 32 years. The amount of electricity produced by each reactor was fixed (favorably for the utilities) and these amounts could be transferred from one reactor to another, thereby extending the lifetime of individual reactors beyond 32 years.

After a conservative victory in 2005, the decision to phase-out nuclear energy was again up for debate and change. Industry and utility companies took advantage of a 'sympathetic' government to urge a change in the timing of the phase-out and using nuclear energy as a long term 'bridge' between the fossil and renewable eras of energy production. After its re-election in 2008 the conservative Government proposed a law extending the time limits for the phase-out and providing even more flexibility for energy utilities (Renn and Dreyer, 2013). In 2010 Chancellor Merkel was about to complete an agreement with the large power companies which both enabled a raise in the spent fuel tax and postponed the phase-out of nuclear energy. Although the government denied any link between the two measures, the German public and most of the media were convinced that this was a deal made in secret. Opposition parties charged the government with compromising public safety in exchange for increased revenues. Many environmental groups organized large demonstrations against the government's plans (Buchholz, 2011).

4.4 *Energy policies after Fukushima*

In the middle of this heated debate, the Fukushima accident occurred and this contingent event altered the political balance. A few days after the accident, the conservative party lost an election in the key German state of Baden-Württemberg, and, for the first time in German

history, the Green party won the majority of the votes and could make one of its leading party heads the Premier of the State.

The federal government responded by deciding to shut down seven of its oldest nuclear units and not re-open one that was out of operation at that time (Renn and Dreyer, 2013). In addition, they requested the German nuclear safety commission to conduct a stress test on all remaining 11 nuclear units in Germany (DG Energy 2011). Within a few days of the accident, the government also established the so-called 'ethics committee' on the future of energy policies in Germany. This committee did not include experts on energy and nuclear risks. It was composed of elderly statesmen from all political parties, functionaries of the major scientific organizations in Germany, social scientists and philosophers of ethics, and, as usual in the corporatist regulatory style of Germany, representatives from the major civil organizations such as employers' associations, unions, and the two major religious groups, Catholics and Protestants[1]. Their mandate was to develop a roadmap for designing energy policies for the future (Ethik Kommission, 2011). The ethics committee had only six weeks to come up with its recommendations since the shutdown of the older reactors needed to be legally confirmed within that period if compensation payments were to be avoided, another contingent factor which may have affected what was considered. After six weeks, the ethics committee recommended the phase-out of nuclear energy within ten years while promoting energy efficiency and installation of renewable energy sources. They recommended reduction of the amount of CO2 emitted in 2015 to 20% of the emission levels of 2005. They also recommended that the government should establish both an auditing committee to make sure that the Energiewende would run smoothly, and an energy public forum to boost acceptance of the new energy policies (Ethik Kommission, 2011; Renn and Dreyer, 2013).

[1] One of the authors, Ortwin Renn, was a member of this committee.

At the same time the Reactor Safety commission issued its report on nuclear safety in Germany. They did not detect any major weakness in German reactors and thought there was a high degree of resilience even for events beyond the design parameters used for licensing these reactors. However, they also concluded that older reactors would be vulnerable to large earthquakes and all reactors to terrorist attacks (Bruhns and Keilhacker, 2011). In June 2011 the German Parliament adopted the recommendations of the ethics committee. All parties in the German Bundestag voted in favor of the Energiewende, with only a few representatives voting against the law or abstaining. The law mandated a phase-out of all remaining nuclear power plants by 2022. In addition, the new law included provisions to reduce the share of fossil fuel from over 80% in 2011 to 20% in 2050. Energy efficiency was to be increased by 40% compared to the average efficiency rates of 1990. The reactors shut down immediately after the accident, remained closed (Renn, 2011).

In a poll taken directly after the Fukushima accident, 78% of the German public approved the new stance of the German government (Renn and Dreyer, 2013). The IPSOS international survey, conducted in June 2011, showed that only 9% of the German population believed that nuclear energy could provide a viable long-term solution to energy needs. This was the lowest percentage of the 24 countries in the survey (Germany shared that position with Sweden). The strong antinuclear attitude among the German population almost certainly reinforced political party support for the transition towards a non-nuclear future in Germany, and the rapid transition of conservative forces to a new outlook.

Between June 2011 and 2015 the new Energiewende law had major effects on energy supply and consumption. The share of renewable energy in energy production increased dramatically from 17 to 28% and the share of nuclear fell from 23 to 16%. However, the share of lignite increased but stabilized after 2014. This eventuated due to favorable weather, with much sun

and wind, with the spot market prices for electricity falling to an all-time low, which led to a situation where gas or even hard-coal fired power plants were not competitive. Only power plants running on cheap (CO_2 intense) lignite were able to make a profit. As a result, the share of lignite coal increased at the same rate that the nuclear share decreased.

A paradoxical situation emerged: the more that Germany invested in the Energiewende (it poured in more than 27 billion Euros in energy subsidies, financed by energy consumers), the more the amount of CO_2 increased because lignite remained competitive in the liberalized energy market (Chrischilles and Bardt, 2015). The government tried hard to overcome this problem by suggesting limits for the use of lignite or offering new payment schemes with flat rates for energy security (which would keep gas fired stations for backup service in business). At the end of 2015, these plans have only been partially implemented.

In 2015, the share of lignite in electricity production dropped for the first time after 2011, though by a mere 0.3 percent compared to the 2014 level. For the first time, also, renewable energy sources provided more energy in terms of Kilowatt hours (40.9 percent) than lignite (39.4%). In spite of this slight progress in implementing the energy transformation, it is expected that the German government will introduce new legal provisions to curb lignite production and consumption in the near future. While some of the local population at the lignite sites in East- and West-Germany feel encouraged by the new boom of lignite and are lobbying hard for a program that keeps lignite as the main fossil fuel source in Germany, other locals protest against expansion of lignite mines and the destruction of their self-sufficient, renewably powered, villages (see Morton this issue).

Table 1 provides an overview of the development of energy sources for electricity production from 1990 to 2015 (adopted from AG Energiebilanzen, 2016). The phase out of nuclear

energy has already resulted in a decrease of nuclear share of the power markets from 27.1% in 2004 to 14.1 in 2015, while the share of coal has remained at roughly similar levels over the last 10 years, with hard-coal reducing from 22.8% in 2004 to 18.2% in 2015, and lignite slightly decreasing from 24.6% in 2004 to 24.0 in 2014 (IWK, 2015; AG Energiebilanzen, 2016). So there is a long way to go.

Electricity Production in Billions of Kilowatt/hours in Germany

	1990	1995	2000	2005	2010	2014	2015
Lignite Coal	170.9	142.6	148.3	154.1	145.9	155.8	155.0
Nuclear Energy	152.5	154.1	169.6	163.0	140.6	97.1	91.8
Hard Coal	140.8	147.1	143.1	134.1	117.0	118.6	118.0
Natural Gas	35.9	41.1	49.2	72.7	89.3	61.1	59.6
Oil	10.8	9.1	5.9	12.0	8.7	5.7	5.4
Renewables	19.7	25.1	37.9	62.5	104.8	162.5	195.9
Other	19.3	17.7	22.6	24.1	26.8	27.0	26.1
Total:	549.9	536.8	576.6	622.5	633.1	627.8	652.7

Germany imports much less electricity (40 Terawatthours in 2014) than it exports (75 Terawatthours in 2014) (Statistica, 2016)

It should be noted that these numbers refer to electricity that is consumed (megawatt hours) not the installed productive capacity in megawatts. The installed capacity of all electricity producing facilities in Germany amount to 199 billion Watts. The share of renewable energy is 94 billion Watts, including 39 billion for solar and 41 for wind energy. Although renewable energy sources supply almost half of the installed capacity in Germany, only 16% of all electricity is produced by them. This gap is due to the volatility of the energy supply (BMWE, 2016). If the wind does not blow or the sun is not shining, the installed capacity does not produce any electricity.

The government has been unable, so far, to provide a feasible plan to overcome the volatility of renewable energy by installing enough backup capacity and storage facilities to compensate for periods of low wind or low solar radiation (Kleinert, 2011; Renn, 2011). In

addition, public opposition to the extension of high voltage power grids has led to the wastage of electricity from off-shore wind installations, since the power generated there could not be transported to the south of Germany where most of the demand is located. It is possible these ongoing politico/technical problems, indicate a significant gap in moving from goals of energy policy to an overall plan by which the goals may be attained.

Disappointment with the government's energy policies was further fuelled by substantial price hikes in electricity (Bosch and Peyke, 2011). Since the German government guarantees a fixed price for feeding solar energy into the national grid for a payoff period of 20 years, the price for electricity has risen substantially since 2012 because of the dramatic increase of solar panel installations on private property (mostly roofs). The additional costs for feeding electricity into the national grid affects all electricity consumers with the exception of energy intensive industries (Andor et al, 2015). These major increases in electricity prices, proposed to encourage renewable energy, may have lowered parts of the German public's enthusiasm for renewables and the Energiewende; another unintended effect of success.

Even under the constraints of energy price hikes and problems with energy security due to volatile energy consumption, it seems unlikely that Germany will reconsider phasing-out nuclear energy. Nuclear energy has already been surpassed by renewable energy in terms of installed capacity. There is little doubt that the former 23% share of nuclear energy can easily be replaced by the growing renewable energy sector. Second, the consensual agreement to phase out nuclear energy by the ethics committee, as well as the overwhelming majority vote in the parliament, demonstrated the commitment to the Energiewende from industry, the major players in science and technology and from environmental groups. One of the best indicators for the irreversibility of this decision is the nuclear industry's reaction in Germany. Siemens, the construction and engineering conglomerate that had built all 17 of Germany's

nuclear power plans, announced in September 2011 that it would no longer build nuclear power plants anywhere in the world, dropping plans to work with the Russian Rosatom State Atomic Energy Corporation to build new plants (WEC, 2012). All major political social and civil society actors followed the official policy of the German government and prepared for a non-nuclear future. No organized stakeholder group openly opposed the Energiewende, although many disappointed enthusiasts of nuclear energy tried hard to lobby against the Energiewende through internet initiatives and mailing campaigns. However, there was little public resonance, let alone support, for these campaigns.

For the future, the more interesting policy question is whether the ambitious promise to reduce the amount of fossil fuel used from 80% today to 20% in 2050 can be kept. Although Germany is highly committed to combating climate change, a commitment rigorously repeated at the 2015 Paris COP 21 meeting, the German public seems much less concerned about the impact of fossil fuels on climate change than about the safety of nuclear energy. Many Germans felt uneasy with the aim of phasing-out both nuclear energy and fossil fuels, and relying entirely on renewable energy. Given the recent price hikes, the pressure of the unions to keep lignite and the need for energy security, it is not surprising that the public hesitates to welcome an accelerated phase-out of lignite. However, on an abstract level, Germans still support the goals of the Energiewende and seem comfortable with a long-term phase-out of fossil energy.

The success of the policies aimed at the envisioned Energiewende will also depend on the implementation of improved energy efficiency measures. Until now, measures aiming at energy efficiency improvements have been predominantly voluntary and based on market incentives and subsidies.

From 1990 to 2012 the gross national product of Germany increased by 37.2 percent, while primary energy consumption overall decreased by 7.7 percent, and electricity consumption increased by less than the half of the economic growth factor, i.e. 14.6% (Umweltbundesamt, 2013: 10). Germany is one of world leaders in energy efficiency. In a comparative study of 16 countries, Germany was rated best on the ratio between energy consumption and economic performance (ACEEE, 2105). However, the government has more ambitious goals. There is an increasing pressure on the government to initiate new and binding laws since the national goals for efficiency have not been reached over the last two years (AG Enegriebilanzen, 2015a). As most reactors will be decommissioned between 2010 and 2020, the main question is how to secure energy supply and sustain a steady base-load production of electricity while using volatile energy sources such as wind and solar power. There is a good chance that lignite will be even more heavily utilized to avoid problems with energy security and unacceptable price hikes. So highly polluting coal may be essential for keeping the transformation popular, while opening up new opportunities for coal companies to avoid change.

If, however, the Energiewende remains its momentum it could act as a role model for many other countries in the world that sympathize with a phase-out of both nuclear and coal but are reluctant because of economic considerations. If Germany does not succeed, then the era of nuclear and fossil energy may continue, despite the increasing risk of climate turmoil.

5. Conclusions and Policy Implications

This article has described the emergence of energy policies in Germany, highlighting the major transitions over the last five decades. Energy policy in Germany reflects the complexity

of Germany's political system and the responses of people to contingent events and the uncertain consequences of actions. The principles of this system are strongly shaped by checks, balances and conflicts between the States and the Federal government and between the parliament and the courts (Hatch, 1986). There is also a strong corporatist/institutional element in German policy arenas that allow substantial influence from major societal actors such as employers, unions and, since the 1970s, environmental groups. Policy changes and administrative measures are further subject to judicial review and public debate.

The sensitivity of politics to public pressure in Germany has made governments vulnerable to grass-root opposition and street protests (Wagner, 1994). As the public in Germany has been more critical of, and active against, nuclear power than in most other nations, the Government has responded quickly to demands for improved safety and control. At the same time, there is strong pressure from environmental groups to reduce the use of fossil fuel, in particular oil and coal. Pressures from disasters, overseas suppliers, and EU policies also have an effect.

Based on these factors, a major revision of German energy policy occurred, which included the phasing out of nuclear power, the expansion of renewable energies and the introduction of a coal reduction regime (Kern and Löffelsend, 2003). The new policies aim to phase-out Nuclear power by 2021, with fossil fuel consumption reduced to 20% of the 1990 level by 2050. After the Paris accord of 2015, the German government has promised to examine the possibility of not using fossil fuel for electricity production after 2050. While hardly any influential group in Germany advocates for the continuation of nuclear power, there is a fierce debate about the future role of coal in the energy mix. The first argument is that coal energy is still a domestic energy source and the industry employs roughly 120,000 workers (Lauber and Jacobsson, 2015). Local communities around coal mines as well as the powerful mining union can advocate for continued coal production and consumption as securing energy security and

supporting local economies (Moeller et al., 2014). Hardly anyone overtly questions the need for reducing coal consumption but the timing of the phase-out can appear too ambitious, with some advocating a slower and more socially practical exit from coal. The second argument relates to the volatility of renewable energy. To secure energy security, backup facilities are necessary if the sun is not shining or the wind not blowing. Since most coal fired power plants are already fully financed they could be economically sustained in operating mode as such back-up. Originally, the plan was to replace coal by gas but it turned out cheaper to keep old coal fired power plants than to build new gas powered plants (Hohmeyer and Bohm, 2015). This, together with the phase-out of nuclear energy, is one of the main reasons why CO2 emissions increased from 2011 to 2013 even though the share of renewable energy was dramatically increased from 17 to 26% of the electricity production. Difficulty of planning is intensified by the uncertain future requirements in a changing system.

The third argument relates to the enormous subsidies put into the energy market. In 2014, German electricity customers paid more than 27 billion Euros to fill the gap between market price and the guaranteed price of renewable energy production (Chrischilles and Bardt, 2015). Many economic analysts believe that Germany will not be able to afford these amounts in the coming years. Coal advocates in particular have embraced this argument to suggest that coal power would reduce the financial burden on electricity consumers.

Lastly, the new energy situation in Germany has led to a new unequal distribution of income and opportunities (González-Eguino, 2015). While the more than 40,000 private producers of solar energy can enjoy a guaranteed income from selling electricity that is far greater than present interest rates on capital, poorer sections of society have to pay for these guaranteed prices. Average household electricity prices have been risen to three times the level of 2010 prices (Andor et al, 2015). This has produced some disenchantment with the Energiewende

and nostalgia for the ‘golden age’ of coal. The income inequalities associated with ‘liberalization’ did not produce similar policy concern, no doubt because they increased ‘normal’ inequalities rather than produced new ones. Whatever one’s view on this issue, there is no evidence that liberalization, by itself, would fix the problem of GHG emissions.

A clear message for policy makers from this history, is the necessity of being prepared to attend to the paradoxical effects and unintended results of policy. This includes the forest dieback from the early attempts to clean coal, the increase in lignite consumption from the success of renewables, the increase of CO2 emissions from 2011 to 2014, the unpopular price increases brought about by attempts to popularize renewables, the conflicts over villages destroyed for lignite mines and so on. Contingent events such as technological accidents (Chernobyl and Fukushima) and time limits appear to affect decision processes, and some corporate interests seem resilient and able to take advantage of change (even if to slow that change) while others do not. Furthermore, liberalization easily changes into the subsidy of powerful economic actors.

Interestingly enough, carbon sequestration (CCS) has never gained much popularity in Germany. After local communities protested against the first experimental storage facilities in northern Germany, the idea of CCS has lost attractiveness among political parties as well as stakeholders (Dütschke et al., 2015). It must be seen, if in the aftermath of the 2015 Paris accord, CCS might get a second chance in Germany, despite its acknowledged problems (see Marshall in this issue).

At this current moment, it is not clear how the energy supply system will finish up, as the transition continues to produce surprising results. It is, however, unlikely that Germany will revoke its anti-nuclear policy but it is still not clear if in light of growing costs and the

inability to compensate for volatile energy generation from renewable sources, coal will experience a longer presence in Germany's energy generation and consumption than presently envisioned by the German government. It is unlikely that the share of coal will increase over the longer period, but the ambitious plans to reduce all fossil fuels to 20% of current consumption by 2050 may undergo serious revision. It is clear that coal will play a significant role in the interim, but no politically powerful group (outside of the coal companies) is advocating a reinvestment in coal. The timing may be slower than anticipated, but the golden era of coal is unlikely to reappear.

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