instruments which are intended to support Energiewende implementation. The integration of national electricity markets into a single common European market strengthens the influence of EW in Germany's neighbour countries.

This study follows the relation between the energy transition in Germany and the Czech energy sector in detail. The first chapter analyses Energiewende itself, its historical evolution, goals and basic instruments. We also show how EW has changed the German energy sector. In the second chapter we focus on the impact of the development of renewable sources on the operation of the liberalized regional electricity market. Chapter 3 introduces the construction of the common EU electricity market and the connection mechanisms of the individual national markets. In chapter 4 we discuss the possible future evolution of the electricity market in relation to the degree of renewable sources development. Chapter 5 explores Czech energy strategy and its compatibility with the changes on the regional market brought about by Energiewende. The last chapter, Chapter 6, deals with the Europeanization of Energiewende, or more precisely, Germany's conscious or unconscious activities which shift the goals, interests and instruments of this policy to the EU level.

1.

GERMAN ENERGY TRANSITION – ENERGIEWENDE

This chapter provides the detailed information needed to understand the energy transformation in Germany. Energiewende (EW)[1] is not simply an evolutionary change which partially impacts particular energy sources and their use, but a complete reconstruction of a modern industrial country's energy sector which is incomparable in Europe.

Energiewende is also an important test case for countries inside and outside of the European Union. The success of this concept would mean a significant reformation of other national power industries, and would thereby challenge the traditional view of the energy mix, management, and organization. The failure of Energiewende would strengthen the persisting skepticism toward the possibility of more significant replacement of fossil and nuclear resources with renewable technologies. A debate on Energiewende can be seen in the meeting of the World Energy Council, where 35 national experts (20 from European countries, 15 from countries outside of Europe) assessed the possibility of extending EW outside of Germany. One third of the participants identified this policy as a possible model for implementation, but half of the respondents completely rejected the idea. The high financial costs of EW were identified as the biggest problem and the abandonment of the nuclear power system

[1] Even though the term Energiewende has been specifically associated with Germany over the last two decades, its origins are significantly older. The term was used for the first time in 1980 in the Öko-institute Energy transition study: Growth and prosperity without oil and uranium. (Energiewende: Wachstum und Wohlstand ohne Erdoel und Uran) (Buchan D., 2012, p. 4)

was thought to be too fast. The most important output of the meeting was that three-fourths of the experts perceive EW as a threat to European energy security. (Energy Post, 2015)

The structure of this chapter is as follows: First, we analyze Energiewende itself – its structure, the active governmental policy which governs it, as well as its development, fundamental regulatory instruments, and stakeholders. Next we explain the impacts of EW on the energy sector of the Federal Republic of Germany from several perspectives, specifically, the source mix transformation, the import and export of electric power, and network stability. Then we focus on the financial aspects of EW, and its costs and influence on electricity prices. We have also added a chapter dealing with public opinion, as this issue is fundamental to the continuation of EW.

1.1 Origins and development of Energiewende

Energiewende stands on two basic pillars: nuclear power phase-out and climate protection measures, both of which are strongly interconnected and mutually reinforcing in German politics.

Nuclear energy was an important element in the building of the power sector in post-war (western) Germany. Together with domestic coal, nuclear resources were meant to provide a sufficient amount of safe (in terms of fuel import) and cheap energy. Given the financial demands of nuclear technology, however, German companies were skeptical of the investments needed. Thus the government began to subsidize nuclear development. By 1967 they had invested a total of 5.3 billion Deutsche marks, and by 1972 they had added almost 6.7 billion marks more. This meant that by the 1970s, Germany already had 17,000 MW of nuclear capacity. (Hake, 2015) There was a broad consensus in the country on the necessity for nuclear power; these resources were seen as the key economic element in both energy security and the reliability of the power supply.

The situation began to change at the end of the 1960s with the formation of the political movement referred to as the Extra-parliamentary Opposition (Ausserparlamentarische Opposition). This movement consisted of leftist students who were disappointed by the persistence of the great coalition of the SPD and CDU, and the Vietnam War, and they promoted socialist topics. Environmental issues gradually permeated into their rhetoric, eventually crystallizing into resistance against nuclear energy. These issues then began to be adopted by both governmental and non-governmental parties.

The planned nuclear power plant in the town of Wahl near the border with France played an interesting role in the formation of the German anti-nuclear movement. Its construction was announced in 1973, and was followed by increasing numbers of organized protests by students from nearby Freiburg. Local farmers also joined these protests (the proposed site was in a wine region), as did some scientists. The growing pressure led to a withdrawal of the construction plan in 1983. In addition to strengthening the anti-nuclear sentiment of some non-governmental groups, the discussed power plant also played a considerable role in the formation of the Green Party. (Morris & Pehnt, 2014, p. 53)

Thus the original consensus on the necessity for and benefits of nuclear energy was progressively disrupted. The accident at the Three Mile Island nuclear power plant in 1979 and the difficult negotiations over the nuclear waste depository in Gorleben also contributed to the situation. The first studies on a possible nuclear-free Germany emerged (e.g. Future of Nuclear Energy Policy from 1980, initiated by Bundestag) and the strongly anti-nuclear Greens entered parliament in 1983. Their role was nevertheless marginal in comparison with the anti-nuclear CDU/CSU, SPD and FDP.[2]

In April 1986, the Chernobyl disaster occurred. This accident had a dramatic impact on the situation in Germany. Surveys of

[2] Christian Democratic Union of Germany, Christlich Demokratische Union Deutschland; Christian Social Union in Bavaria, Christlich-Soziale Union in Bayern e.V.; Social Democratic Party of Germany, Sozialdemokratische Partei Deutschlands; Free Democratic Party, Freie Demokratische Partei.

public opinion carried out during the following weeks showed the significant dominance of proponents for the shutdown of nuclear sources (86 %), and 17 % of respondents demanded the immediate shutdown of these sources. (Hake, 2015, p. 536) Also, the attitude of the main political parties changed when the SPD came out in favor of the anti-nuclear camp. The 1980s thus saw the beginning of the deterioration of German confidence in the future of nuclear technology.

In light of the evolution of Energiewende, another aspect of the nuclear industry is also interesting. From the very beginning, resistance against the industry served as a unifying force for all of the possible environmental and climatic movements in German society.

In the 1970s, growing anti-nuclear sentiment and environmental consciousness raised the issue of renewable energy sources (RES). This was stimulated by the oil crises, specifically, the problems with the oil supply from the Middle East in 1973/1974 and 1979[3]. In 1974, the first RES governmental subsidy program was launched in the amount of 10 million marks. It focused above all else on photovoltaic systems. In 1977, a system of subsidies was introduced which provided investors with 25 % of the costs of solar panels and heat pumps. By the end of 1982, 150 million marks had been invested from the public budget into RES.

The 1980s and '90s saw a period of a growing pressure to deal with climate issues, including many inner-German and international commitments for the reduction of carbon dioxide emissions. It is interesting that the strongly environmentally active German society did not associate these issues with (low-carbon) nuclear technology. Only the political parties, above all the CDU/CSU and FDP, typically followed this line of reasoning. Thus the defining features of these years were the growing

[3] Of course, the link between the oil crises and RES support was not and is not immediate. Renewables are today used primarily as sources of electric power, and their use in transportation is limited. However, the oil crises did draw attention to the general problem of society's dependence on limited and imported fossil fuels and in that way emphasized the need for RES.

distrust of nuclear energy and the intensive effort made in the development of renewables.

In 1990, the distrust culminated in the adoption of the Act on the Supply of Electricity from Renewable Energy Sources into the Grid. (Stromeinspeisungsgesetz, StrEG) The Act imposed the obligation to accept power from RES on network operators, and energy companies[4] had to pay producers a certain minimum purchase price which was derived from the market price of electricity. (Hake, 2015, p. 8)

The year 1998 saw a significant step forward in the evolution of Energiewende when the Greens were, for the first time, part of the government coalition (with the dominant SPD). Their programme was actually based to a great extent on radical anti-nuclear rhetoric. The Greens' discussion with the governing SPD resulted in the acceptance of a compromise road map which determined both the rules and schedule of Germany's gradual withdrawal from the atom. The road map was introduced in 2000 and adopted in 2002. It contained the following rules: the life span of existing nuclear power plants was limited to 32 years; the amount of energy the nuclear plants were allowed to produce was defined (approximately 2.6 million GWh of combined production over the entire period), and under this policy, the companies were not compensated for the decommissioned nuclear plants. (Hake, 2015, p. 9)

Parallel activities were carried out which focused on strengthening the role of RES. StrEG had proved to be an important, yet insufficient, tool for the development of these technologies. The problem was that the amount of aid was derived from the market price of electricity which was falling in relation to the German liberalization. Therefore the Act on Granting Priority to Renewable Energy (Gesetz für den Ausbau Erneuerbarer Energien, EEG) which calculated the price based on the price of the RES technologies was introduced.

[4] In the 1990s, the separation (unbundling) of the electricity producers and the transmission and distribution grid operators was yet not applied. In most cases it was one and the same company.

The arrival of Angela Merkel's great coalition in 2005 (CDU/CSU and SPD) brought other changes to the German energy policy. During her first term, ambitious plans for climate related issues which later transformed into specific domestic objectives were typical for the Chancellor. The pressure for more RES in the energy mix rose, and both reduction in consumption and energy efficiency were discussed more intensely. All important political party actors supported the German climate goals and environmental policy. The camp of proponents for nuclear energy practically ceased to exist. Parties supported either a faster (SPD, Greens, leftist party Die Linke) or a more gradual withdrawal (CDU/CSU, FDP) from this technology and allowed for the use of nuclear energy as a transitive source on the road toward a system based solely on RES.

The key concept paper of Chancellor Merkel's government was the Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply (Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung). It was publicly introduced in 2010. The concept in fact defined the basic environmental-energy goals which EW is currently striving to reach. (Hake, 2015, p. 10)

There were still several important shifts to come for the nuclear policy, however. In October 2010, the Atomic Energy Act was amended. Production limits for the amount of electricity produced by nuclear power plants increased, and plant lifespan was extended. But soon after, in March 2011, the power plant accident in Fukushima, Japan occurred. This united both the German public and the political elites in their resistance to nuclear technology and the controversial decision was negated. In the same month, a nuclear energy moratorium was announced and the seven oldest nuclear power plants were shut down. In June 2011, a decision was made to shut down the remaining plants by 2022.

1.2 Goals of Energiewende

As previously mentioned, in 2010, the German government defined its basic energy transition objectives in the document Energiekonzept. It was later amended with the request to abandon nuclear energy by 2022.

Tab. 1: The Principal EW Targets

	2020	2030	2040	2050
Greenhouse gas emissions (compared to 1990)	-40 %	-55 %	-70 %	-80 to -95 %
Primary energy consumption (compared to 2008)	-20 %	–	–	-50 %
Electricity demand (compared to 2008)	-10 %	–	–	-25 %
Residential sector heat consumption	-20 %	–	–	–
RES share of electricity consumption	More than 35 %	More than 50 %	More than 65 %	More than 80 %
RES share in the final energy consumption	18 %	30 %	45 %	60 %

Source: (Agora Energiewende, 2014, p. 1)

These basic objectives in Energiekonzept are accompanied by a wide range of partial objectives, commitments and limits. The key question, thus, is to what extent they are binding. In the long-term, it is (in our opinion) necessary to consider them as important indicators which make the formation of specific policies and laws possible, rather than as unalterable dogma. As German society is almost completely unified on EW issues, a well-reasoned adjustment of these objectives, when necessary, would not be a significant complication nor would it be a reason for major political discord.

What is more, the target numbers must primarily be perceived as a well formulated tool that will facilitate the fulfillment of the broader ideological intentions of Energiewende. As laid out in the Energiekonzept, the aim of the transformation is to provide an environmentally acceptable, reliable and affordable energy supply. This shows that EW is not focused merely on climate protection. The document states that "…the world's rising demand for energy will lead in the long term to a pronounced increase in energy prices. Our country's dependence on energy imports would also continue to increase…". (BMWi and BMU, 2010, p. 3) In the context of this and other statements in the Energiekonzept, RES can be seen as a means to ensure both reliable (in the terms of independence from other producer countries) and affordable supply (based on the assumptions that fossil fuel prices will continue to rise and that RES prices will continue to fall thanks to technological innovation).

It is possible to find hints of other motivations for Energiewende in the document. While not included in the official objectives of Energiewende, the vision of export opportunities for German industry is clearly apparent. On its web pages, the Federal Ministry for Economic Affairs and Energy (BMWi, 2015a) states, "New global markets have arisen in the wake of the expansion of renewable energy sources and efficient use of energy…", and that the investments related to the Energiewende "…will reinforce the leading position of German companies in the field of environmental and energy technologies…". (BMWi and BMU, 2010, p. 5) The Renewable Energies Export Initiative was even established in order to support the industry abroad. (BMWi, 2015c)

The search for new opportunities for the German industry is also linked to the general desire for sustainable economic growth. Energiewende stimulates investment, technological advancement and therefore economic growth as well. Unlike many other processes, Energiewende achieves that growth while respecting the environment and acknowledging the finite nature of some natural resources. In the words of Norbert Röttgen (CDU), former Federal Minister of the Environment, "Thanks to Energiewende, the conflict between ecology and economy has finally been resolved…". (Bosman, 2012, p. 3)

Generally speaking, environmental motives and nuclear energy concerns were the main triggers of Energiewende. There were, however, other security and economic motives that were also outlined in the document which may have played an important role in the decision-making of the political elite.

1.3 Regulatory environment of Energiewende

The German energy transition is an extremely complex project which greatly exceeds the boundaries of the national energy sector in terms of the structure of the individual policies, laws and regulations used in its implementation. Although the assessment of these would exceed the scope of this text, it is very well summarized in a BMWi study.[5] In the following section we introduce the basic pillar of the policy – the Act on Granting Priority to Renewable Energy (EEG), and its 2014 reform.

The EEG was adopted in 2000 and its goal was to cover the costs of development of selected technologies. The document defined the two main tools to support RES. The first was financial subsidy. This took the form of feed-in tariffs (FiT) in which purchase prices were guaranteed for 20 years,[6] or alternatively, a renewable energy producer could directly trade the electricity and receive a bonus which was calculated in advance (system of

[5] BMWi: Overview of legislation governing Germany's energy supply system. http://www.bmwi.de/English/Redaktion/Pdf/gesetzeskarte,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf

[6] More simply, the feed-in tariff purchase price calculation mechanism means that the responsible authority (regulator) derives the basic price per kWh by dividing the costs of the selected technology by the number of kWhs expected from a similar source during its lifespan (here 20 years). In the end, the amount of profit resulting from the preference of the particular country is added (usually in units per cent). The guaranteed prices for the new sources change (are reduced) in the defined time periods (annually, quarterly) according to the varying costs of the given technology.

market premium). Secondly, network operators were obligated to preferentially purchase electricity from RES.

On 1 April 2014, the fundamental reform of the EEG was adopted. The reform was predominantly motivated by the three factors. The first factor was the increase in expenditures needed to subsidize RES. The RES subsidies and other related costs gradually increased the price of electricity for German end users to one of the highest levels in Europe, and the government was compelled to respond. The second motive for reform was the desire to bring more renewables to the market. The above-described mechanism for setting purchase prices was, de facto, separating RES from the market. This was because the producers of these sources did not need to respond to any current or long-term shortage or surplus of electric power, price, or the complications (and costs) which were associated with the less predictable production of alternative sources of energy. The reform was intended to prompt RES electricity producers to consider these market signals more seriously. The third reason for the reform was the rising demand placed on a grid which was historically constructed for operation based primarily on traditional (dispatchable) sources. Decentralized RES began to require large investments into the construction of new lines and, moreover, RES market volatility increased both the cost of network regulation and the cost of maintaining the source balance disrupted by the multiplying imbalances.

The reform entered into force on 1 August 2014 and the following changes were introduced:

1) Adjustment of the RES subsidy. The general declared target remained set at 40–45 % of RES in gross electricity consumption by 2025, 55–60 % by 2035 and 80 % by 2050. In order to stabilize the pace of construction that would be necessary to meet the new target capacities, corridors determining the desired capacities of the new facilities for each year and each source were established. In the event of over or underproduction of capacity, the amount of subsidy is adjusted in a way which sends a positive signal to investors. This was intended to lead to a more moderate and, above all, more predictable growth in the RES share of the energy mix.

Tab. 2: Projected capacity of proposed RES facilities (for comparison, the total installed capacity in 2014 is in brackets)

Onshore wind farms	2.5 GW per year (34.6 GW onshore and offshore farms together). The calculation also includes old sources that were shut down during the respective year.
Offshore wind farms	To reach 6.5 GW of the total installed capacity by 2020, 15 GW by 2030 (34.6 GW onshore and offshore farms)
Photovoltaic power plants	2.5 GW per year (37.5 GW).
Biomass	100 MW per year (6.4 GW).
No targets for the geothermal and water energy industries	
Source: (The Regulatory Assistance Project, 2015, p. 13) (BMWi, 2015b, p. 7)	

A system of gradual reduction (monthly, quarterly) of the subsidy, regardless of installed capacity, was also introduced. The trend to support less expensive technologies (PVE and onshore farms) at the expense of the more costly technologies (offshore wind farms) is obvious here.

2) Gradual change in the way RES electricity is traded. First, fixed purchase prices for the new sources (with the exception of small scale production facilities[7]) were eliminated and replaced with a system of market premiums. This was a significant change for producers. In terms of fixed purchase prices, their strategy has become clear: to use a source when weather and technical conditions permit. Market price is not important for them; these producers also want to sell when there is a surplus of electricity.

[7] This is the case of the power plants built before 1 January 2016 with an installed capacity lower than 500 kW and, additionally, power plants with an installed capacity of 100 kW that were put into operation after 31 December 2015. (Lang & Lang, 2015, p. 137)

The switch from fixed purchase prices to market premiums meant, however, that producers would only receive a bonus for electricity they sold on the market themselves. Potential consumers, of course, buy electricity during periods of higher prices[8] (periods of relative shortage) under the assumption that producers will absorb the difference in price between the contracted amount of electricity and the actual supplied electricity. The expectation is that producers will attempt to better manage production and also utilize more short term trades (on power exchange) to adjust for the discrepancy. The energy system as a whole then experiences more stability and lower exposure to the fluctuation of RES.[9]

3) The cancellation of FiT for the new sources is only one part of the RES financing reform, however. EEG reform also introduced auctions as a new mechanism for determining the RES subsidy. This was intended to lower prices, to strengthen RES integration into the electricity market, and to reach a greater compliance with the new EU strategy.[10]

In 2015, this model was tested on free standing (e.g. not rooftop) solar power stations. This process is regulated by the Ordinance for Competitive Bidding for Financial Support of Freestanding Installations (Verordnung zur Einführung von Ausschreibungen der finanziellen Förderung der erneuerbaren Energien, FFAV) and is as follows: Auctions for the total installed capacity of 500 MW were to be held in 2015, for 400 MW in 2016 and for 300 MW in 2017. Individual bids can vary between 10kW and 10MW. The use of agricultural land for new construction was restricted. Two specific financing models were tested. At the beginning of 2015, the first model was applied to the first auction, and each successful participant received the requested amount of financial support. The second model was applied to the second auction. The amount of aid was uniform and was determined by the highest accepted bid (Lang & Lang, The 2014 German Renewable Energy Sources Act revision – from feed-in tariffs to direct marketing to competitive bidding, 2015, p. 138). The experience from these auctions should serve as the basis for determining the support structure for all RES. As previously mentioned, this system should be put in place beginning in 2017.

4) The redistribution of the costs of the RES subsidies has been controversial for some time. The substantial portion of these costs is borne by households. Through the Special Equalization Scheme (Besondere Ausgleichsregelung), Germany, an industrial pro-export country, provided an exemption from the EEG fee to certain enterprises (energy companies, firms involved in international trade, and railway companies). In 2014, the total amount of these exemptions was approximately €5.1 billion. The resulting relatively low electricity prices for German companies, when compared with the rest of Europe, has led to disputes with the rest of the EU, and there have been discussions regarding the unfairness of the state aid. The exemption also raises the kWh price by 1.35 cents for the consumers for whom it does not apply (households, smaller firms). (Dinkloh, 2014) The European Commission launched an investigation into the public aid of the exempt companies.

The EEG reform adjusts this scheme, inter alia in accordance with EU requirements for limiting state aid. The financial support will continue for companies which are significantly threatened by electricity prices and which consume at least 1GWh of the electricity that is subject to EEG. The fee is calculated in the following way: the first GWh is paid

[8] EEG reform also directly deals with the problem of the negative prices of electricity. In the event that the price of electricity for the German-Austrian commercial zone is negative on the spot market of EPEX Spot SE in Paris for six consecutive hours, the support will be restricted until the prices reach positive values. (BMWi, 2015, p. 18)

[9] Variable in the terms of substantial dependence on the weather cycles. This means, above all, wind sources and photovoltaic.

[10] The Guidelines on State Aid for Environmental Protection and Energy 2014–2020 lay down the new framework rules for the RES subsidy across the EU. According to these guidelines, beginning in 2017 the RES subsidy should be determined using the auctions.

at the full fee amount, and for each additional GWh the fee is reduced. Specific conditions are also applied for railways. Furthermore, the implementation of the system is gradual, giving the companies time to adapt to the EEG reform. (Lang & Lang, n.d.)

In 2014, the total number of subsidized companies increased to 2452, compared to 2388 one year earlier. This increase was especially seen in the railway sector (123 applications for fee reduction). Total company savings were expected to be approximately €5.1 billion.

5) The rules governing the use of RES electricity consumption by the producers for their own needs were also tightened. Producers (large producers, in particular) must now also pay the RES subsidy fee, however not at the full rate.

On the other hand, EEG reform leaves all of the basic principles of Energiewende unchanged, or with only slight adjustments. RES remain favorable because the subsidy raises the price to a level which is above the market price. This financial aid is guaranteed for a period of 20 years, plus one year for bringing the operation online. For new power plants, the subsidy is dependent on the date of installation and is gradually reduced to reflect technological progress and the price reduction of technologies. Grid operators have to pay the EEG fee for the renewable electricity they receive and they are obligated to connect the RES sources to the grid. The burden of EEG financial support remains on consumers. (Lang & Lang, The 2014 German Renewable Energy Sources Act revision – from feed-in tariffs to direct marketing to competitive bidding, 2015, p. 134)

As for the development of further legislation, another revision of the EEG should be carried out in 2016. It will address the preparation of the above described auction system.

1.4 Energiewende actors and attitudes regarding the transformation

Energiewende influences and is influenced by many various actors and the interests of these actors have a significant impact on the shape and direction of the entire process. The following sub-chapter therefore introduces the most important actors in the field of German politics and their attitudes towards EW.

1.4.1 Political parties

The basic features of the energy policy are determined at the constitutional level. Here the attitudes of the main political parties meet and these we are now going to describe.

CDU/CSU

As previously stated, during the first post-war decades there was a wide consensus in Germany regarding the necessity for nuclear energy. The positions of all the established political parties (CDU/CSU, SPD and FDP) were based on this consensus and remained unchanged into the 1970s and the first half of the 1980s when the unity of public opinion regarding this issue started to fall apart. (Hake et al., 2015, p. 4–5)

The conservative CDU/CSU were among the strongest supporters of the atom. At the same time, both they and the industry remained skeptical of the vision of the strengthening environmental circles who saw the future of energy in renewable resources. Helmut Kohl entered office in 1982, and his government halved the expenditures for RES as a part of austerity measures. (Hake et al., 2015, p. 6)

The means for RES development were again increased after the Chernobyl accident in April, 1986. In reaction to the change in the social climate, the coalition government of the CDU/CSU and FDP established the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Previously dispersed competences were brought together under this new ministry. Nevertheless, despite clear public resistance and the about-face of the SPD opposition, the governing parties did not question the necessity for nuclear energy.[11] (Hake et al., 2015, p. 5)

While in the 1990s the Christian Democrats' underlying belief in nuclear energy remained, their approach towards renewables gradually changed. In 1987, Helmut Kohl spoke of the "…serious threat of climate change resulting from the greenhouse effect…" (German Energy Transition, 2015). A group of conservative deputies began to work with the Greens on a new legislative tool to support RES. This was partially due to the influence of the new ministry (BMU) and lobby groups. The result was the aforementioned 1991 Act on the Supply of Electricity from Renewable Energy Sources into the Grid (StrEG). (Hake et al., 2015, p. 8)

The support of RES became a unifying element in the politics of the energy industry. (Kemfert & Horne, 2013, p. 1) The conflict before the 1998 elections therefore formed around the nuclear energy issue.

The elections resulted in a government of the SPD and the Greens which focused its energy policy on EEG law and plans to phase out nuclear power plants by 2022. The CDU/CSU and FDP opposition criticized both actions, partly because the EEG diverted the RES support from the principles of market economy which were preferred by these parties.

Before the 2005 elections, the CDU/CSU changed their rhetoric. Instead of abolition of the EEG, they began demanding that its tools be improved. In spite of the fact that the conservatives subsequently created a coalition with the SPD who supported both the EEG and the nuclear phase-out, policies in this domain remained untouched. Chancellor Merkel focused on the area where there was a congruence with their coalition partner, i.e.

[11] A certain concession to public opinion was made when the government decided not to build new nuclear power plants until the opinion of the public changed (Hake et al., 2015, p. 6). The government was not willing to shut down the existing facilities, however.

on laying out and implementing climate policies. (Hake et al., 2015, p. 9)

In 2009, the government of the CDU/CSU and the (also pro-nuclear) FDP replaced the great coalition. This freed the hands of the conservatives to change the nuclear policy. Chancellor Merkel's cabinet delayed the definitive shut down of the nuclear power plants by 14 years. In this phase, the CDU/CSU acknowledged the vision of a nuclear phase-out but cited the atom as a safe, affordable and environmentally friendly "bridge" into the RES age. It was precisely the development of the alternative sources which the government had supported in the Energiekonzept. (Hake et al., 2015, p. 10)

After the accident in Fukushima in March 2011, public support for nuclear energy dropped to 20 %. The government came under pressure from the opposition, the public and the media. Public opinion on this issue began to impact the popularity of CDU/CSU. One survey (successfully) predicted that the third most populated German state and long-term bastion of conservatives, Baden-Württemberg, would be dominated by the anti-nuclear Greens[12] in the upcoming elections. (Beveridge & Kern, The Energiewende in Germany: background, developments and future challenges, 2013, p. 7–8)

Under these circumstances, the government changed its nuclear policy, shut down the seven oldest nuclear power plants and later restored the red/green coalition plan to disconnect the rest of the facilities from the network by 2022. (Beveridge & Kern, 2013, p. 8)

It is questionable to what extent the Christian Democrats identified with the decision they had long resisted and which was probably made only in the face of public opinion. According to Kemer and Horne (2013, p. 5), a part of the CDU/CSU has continued to support the original energy system. However,

[12] There were several reasons for the decline of the CDU in the regional elections (discontent with the solution of the Euro crisis, resistance of the public against the big railway development project Stuttgart 21 etc.), but the issue of the atom was undoubtedly one of them. (Beveridge & Kern, 2013, pp. 7–8)

because of the social climate[13] we cannot expect a change in the official party attitude unless a dramatic change of conditions occurs.

Thus a political and social consensus regarding the new energy system was established. There did remain certain differences in opinion on the form of its implementation, however, for example the role of industry and the way Energiewende is financed. Specifically however, the CDU/CSU had a relatively vaguely worded platform for the energy sector during the 2013 federal elections. The plan mentioned the integration of RES electricity into the domestic market and the creation of a common European energy market, but the specific policies remained unclear. The reason for this was most probably the intention to leave an opening for all potential coalition partners. (Kemfert & Horne, 2013, p. 11) In this respect the CDU/CSU succeeded. The above described EEG reform, approved by the coalition of CDU/CSU and SPD, shows the ability of the two biggest parties to reach a common solution in spite of the fact that the conservatives are more likely closer in their views to the FDP, whereas the SPD is closer to the Greens.

FDP

The liberal, center-right FDP is a smaller party, which traditionally supplements one of the main parties (CDU/CSU and SPD) as a coalition partner. While their views on nuclear phase-out and RES development have evolved in relative accordance with the conservative party attitude, their pro-nuclear position has generally been even a bit more conservative. Above all, the FDP has tried to keep RES subsidies within market boundaries. Before the 2005 elections, the FDP was the only party that still rejected the EEG implemented by the SPD and the Greens. The party finally accepted the EEG reform just before the 2009 elec-

[13] Rural areas, which represent the traditional electoral base of the CDU/CSU and which are significantly involved in the building of the RES installations, also support the withdrawal from the atom and its replacement by RES.

tions. This resulted in a German political consensus on the ambitious climatic objectives and support of RES using the EEG. (Hake et al., 2015)

In the 2013 federal elections, the liberals called for a faster integration of RES into the market and for certain measures[14] which align with the interests of the traditional centralized energy sector. Because of their call for reform, Kemfer and Horne (2013, p. 5) refer to the FDP as informal opponents of Energiewende. The party failed in the elections (for the first time in history they did not get into parliament), however, and thus do not have such an important influence on the current situation.

The Greens

The German Green party was established in 1980. The anti-nuclear movement, environmental organizations and much of the peace movement played an important role in the process of party formation. The party got into parliament as early as 1983. One of their main political objectives was the immediate shutdown of all nuclear power plants in Germany. RES development went hand-in-hand with this goal. (Hake et al., 2015, p. 5) The Greens, thus, were the first party to strive for the implementation of Energiewende.

The German Greens became one of the most successful green parties in the world. This can be partially explained by the growing support for the party by the anti-nuclear movement. (Beveridge & Kern 2013, p. 5) Until the Chernobyl accident, however, when the anti-nuclear camp was joined by the social democrats, the party stood in isolation in the parliament. (Hake et al., 2015, p. 5)

The first significant mark made by the Greens on the German energy policy was in collaboration with some representatives

[14] E.g. advocating for a European quota model instead of the national EEG or entitlement of the Federal Network Agency to temporarily stop the feed-in priority of renewables. (Kemfer and Horne, 2013, p. 11)

of the CDU/CSU on the draft law for support of RES (StrEG). The party gained a wider field for maneuvering in 1998 when it appeared as a potential coalition partner in the government with the SPD. The Greens conditioned their participation in the government on the fastest possible shut-down of the nuclear power plants. The resulting compromise plan was a success for the party, albeit a partial one. It was approved in 2000 and it fixed 2022 as the year for the shut-down of the last nuclear power plant. (Hake et al., 2015, p. 8) This was, in conjunction with pushing through the EEG, the step which completely changed the German energy policy and de facto initiated the present Energiewende.

The Greens sharply criticized the temporary reversal of the decision on nuclear phase out made by the conservative-liberal government. In reaction, they joined forces with the leftist party Die Linke, environmental organizations and unions. Together they organized industrial protest actions with tens of thousands participants. (Hake et al., 2015, p. 11)

In the 2013 election campaign, the Greens presented themselves as the advocates for the current shape of Energiewende. They advocated for the establishment of the special Federal Ministry for Energy and Environmental Affairs and called for the intermediate steps which would make the transformation more socially inclusive. (Kemfert & Horne, 2013, p. 12)

SPD

The Social Democrats were the first of the established parties to take the side of the anti-nuclear camp. As early as the second half of the 1970s when public opinion on nuclear energy started to take a negative turn, there were critical voices inside the SPD which disrupted the party consensus. (Hake et al., 2015, p. 5) A change in party attitude was brought about by the Chernobyl accident, after which the SDP converged toward a vision of an atom-free Germany. (Beveridge & Kern, The Energiewende in Germany: background, developments and future challenges, 2013, p. 5)

In 1998, when the Social Democrats came to power after 16 years of a CDU/CSU and FDP government, they enforced, in conjunction with the Greens, the EEG and the plan for the shut-down of the nuclear power plants. The postponement to 2022 was pushed through by the SPD alone, as the party was afraid of an increase in electricity prices and job losses in the nuclear industry. (Hake et al., 2015, p. 8)

The SPD also participated in the climatic initiatives of Angela Merkel's first cabinet. However, they were replaced by the FDP in the second coalition government.

The Social Democrats' energy programme in the latest federal elections was close to that of the Greens. Despite the party's historical links to the coal industry, the SPD presents itself as a categorical advocate of the transition to an energy system in which RES plays a primary role. The SPD approved of the current shape of Energiewende, but strove for the improvement of its management through the establishment of the Federal Ministry for Energy and the German Energy Council. (Kemfert & Horne, 2013, p. 11) Furthermore, the SPD strongly advocated for the electricity tax reduction and the adoption of legislation regulating the prices for end users. (Mason, Energiewende: Electricity bills and Germany's election, 2013)

Within the framework of the great coalition that resulted from the elections, the SPD participated in the above described EEG reform. Although the reform did not reflect the party's energy election plan, it would indirectly contribute to their goal of reducing the transformation costs for consumers.

Die Linke

In 2007, two parties, each with a regionally limited sphere of influence, merged and created the national far-left party Die Linke. This party has thus far not played a significant role in the formation of the German energy policy. Nevertheless, the party, much like the SPD and the Greens, favours the intensive implementation of Energiewende. Unlike the SPD and the Greens, however, they advocate for a total socialization of electricity producers and the transmission grid. (Kemfert & Horne, 2013, p. 12)

1.4.2 Competence structure and its risks

While difficult to achieve, effective coordination is crucial for the implementation of a project as complex as Energiewende. On the following pages we briefly outline the competence structure of Energiewende and the risks posed by that structure.

The most important actor in the practical implementation of Energiewende is the Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, BMWi). The ministry was established in 2013 and was transformed from the former Federal Ministry of Economics and Technology. It consolidated the majority of the competences related to the energy industry. Previously, these competences had been distributed among several ministries and had, in some places, overlapped.

Besides the BMWi, specific aspects of Energiewende fall under the administration of 5 other ministries, at least 11 federal agencies or offices, 3 municipal associations and many regional institutions.

The structure of Energiewende management suffers from certain problems. As was seen in the election platforms of the last federal elections (see above), there was discussion regarding the intersection of the competences at the ministerial level. This was not resolved by establishing a separate ministry, as the SPD and the Greens had hoped, but by consolidating the key energy competences under one ministry. However there are also other problematic areas of EW management. We outline three of them which we consider to be the most important.

Interests and the influence of the federal states.

Within the federal organization of Germany, the federal states (so called Länder) play an important and powerful role and are therefore able to limit the federal government in the implementation of its decisions. This happens, inter alia, through the Federal Council (Bundesrat) which is comprised of the representatives of the federal states and which is similar to the Upper Chamber of Parliament in the other countries. The representatives are able to restrict the maneuvering area of the government; in particular, in the cases when there are different political parties in power at the state level than at the federal level. (Kemfert & Horne, 2013, p. 11)

Within Energiewende, the power of the Länder is seen most in the process of the expansion of the new transmission grid. This expansion often stops on the border of the federal states which, in conjunction with the municipalities, are responsible for a great part of the approval procedures for the extension of the network. (IEA, 2013, p. 32) As is shown in chapter 5.1.1, Germany takes steps to improve and facilitate this process. Nevertheless there is a persistent failure to construct the network according to the plans, primarily because of local opposition. According to Kemfert & Horne, (2013, p. 6) this is also because of the half-hearted attitudes of the transmission grid operators.

The federal states are able to act not only against the federal government but also against each other. The second point of friction in Energiewende in regard to the German federal organization is conflict among the particular Länder about the placement of large RES installations. While southern states want to massively build solar or biogas power plants on their territories, the northern part of Germany is lobbying for a larger area to exploit its wind potential. If the requirements of both parties were to be fulfilled, an excessive amount of production capacities would be built. But Germany already took steps to overcome this obstacle when in 2013 the federal states agreed on more cooperation and on moving certain competences to the federal level. (Kemfert & Horne, 2013, p. 6)

Changes in administration

Energiewende has been a project for at least 40 years but the administration which implements it changes every few years. Kemfert & Horne (2013, p. 11) perceive the uncertainty over the future management of the governmental institution as an unknown which influences the effectiveness of the project implementation. This is undoubtedly true, but at the same time it is necessary to add that as long as Energiewende is supported by the overwhelming majority of the public (see chapter 1.7), the formation of a government striving to fundamentally jeopardize or reverse the transformation is not probable. Potential deviations in Energiewende implementation can be limited, as Sopher (2015, p. 3) suggests, by transferring more competences to governing bodies (various federal authorities and offices) whose staff does not change according to the electoral cycle.

European Union Restrictions

As we show in detail in the chapter 6, the German energy policy exists within the confines of the European energy policy. So when these policies are incompatible, the implementation of Energiewende can become more complicated. For example, Pegels & Lütkenhorst (2014, p. 532) worry that a potential common European energy policy on RES support could be based on the least common denominator of member state interests and therefore could endanger the more ambitious German Energiewende. This may be one of the reasons why Germany refuses the harmonization of the support schemes (more in the subchapter 6.2.2)

1.4.3 Private actors

In addition to public institutions, a whole range of private actors participate in the planning process and implementation of the Energiewende. These are energy producers, transmission grid operators, industrial enterprises (mainly energy-intensive sectors), lobby groups, citizens associations, NGOs and so on.

Private actors played a significant role in advancing the Energiewende concept into German public discourse. Bosman (2012, p. 2) sees the cause of Energiewende "in the success of an influential coalition of renewable energy supporters, who have managed to convince a majority of the public and the political classes that an energy system based on decentralised, renewable energy sources is feasible and indeed in many ways beneficial to the environment as well as to the economy".

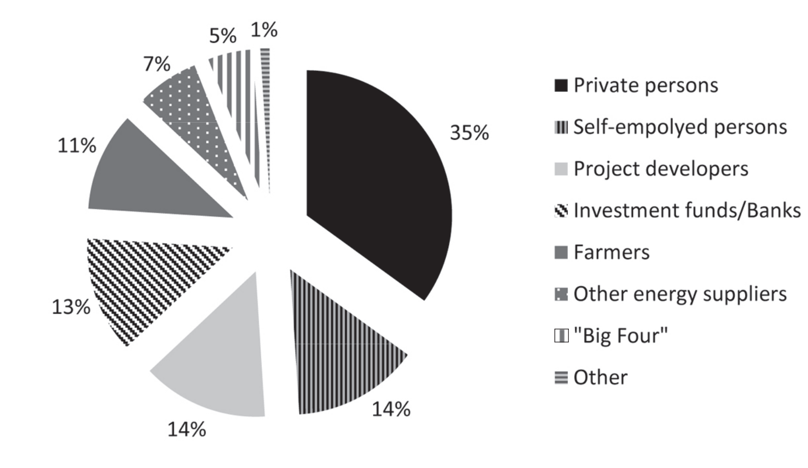
As is clear from the data in the chapter 1.7, the overwhelming majority of the public support Energiewende. It is generally thought that Germans are unified on this issue and this publication is based on this presupposition. However it is also obvious that not everyone in Germany agrees with the transformation. Therefore, in the limited space of this subchapter we are not going to deal with the private actors who support Energiewende, but rather with those who at least partially disrupt the social consensus.

It should be noted that these are "opponents" in a very specific and, for Germany, characteristic sense of the word, i.e. actors whose objective is not to question the whole policy or to attack it, but those who draw attention to its weak points and the difficulties of implementation. Nevertheless their position also gradually softens and adjusts to the society-wide consensus.

The Big Four

Most of the production facilities in the country are owned by the "Big four" companies: E.ON, RWE, En.BW and Vattenfall. The sudden decision to quickly leave the atom after the Fukushima power plant accident in 2011 resulted in large financial losses for these companies. Based on the previous agreement, the companies actually counted on prolonging the lifetime of these power plants. Not only did this not happen, but pressure to shut down the German nuclear sources even increased. Thus, in 2012, Vattenfall took Germany to the court of arbitration in Washington (ISCID), asking for €4.7 billion in compensation. (Spiegel Online, 2014) E.ON and RWE responded similarly as well, and in summer 2012 they lodged a complaint with the constitutional court. At the same time they also approached the financial court in Hamburg over the implementation of the fuel cells tax which they considered to be in conflict with the state competences defined in both the constitution and in EU law. (Frankfurter Allgemeine, 2012) At the beginning of 2014, E.ON received compensation from the German state in the amount of €380 million for shutting down the power plants Unterwesser and Isar 1. This was followed by RWE's compensation claim of €235 million for the Biblis power plant. (Spiegel Online, 2014)

Fig. 1: Owners of RES capacities in 2012



Source: Destatis, 2014

The Big Four's control over the majority of German capacity does not apply to RES (see the graph above). This sector was practically ignored by the large companies as late as 2011. The firms underestimated the potential of RES and thus left this lucrative field to smaller companies, municipalities and individuals. On one hand this fragmented ownership structure may complicate EW implementation, but on the other hand it significantly increases the general public's awareness of these technologies. The financial involvement in RES by both municipalities and smaller actors has helped to overcome certain difficulties typical for the local opposition.

Generally, the Big Four's significant anchorage in the traditional energy industry caused their initial aversion to the whole energy transition. During recent months and years, whether because of internal conviction or under pressure from the changing situation in Germany, all four companies have adjusted and adapted their operations in compliance with EW. For example, at the end of 2014, E.ON announced its split into two companies; one still holds conventional power plants while the other focuses on renewables and the new services and products related to the decentralized and customer-driven energy industry. (Energy Post, 2014)

The transmission network operators

The four transmission system operators (TSOs) can also be placed into the camp of occasional transformation critics. Energiewende requires these operators to extensively extend their networks and the complexity of their operations is increasing, as well. The previous situation, however, brought them a stable and in no way endangered income. (Kemfert & Horne, 2013, p. 6)

Industry

The third group of EW critics is a section of the industrial sector. The sector is divided according to its exposure to electricity prices, competition on the European market, and ability to obtain an exemption from the EEG surcharge. Both factions have their own associations and lobbyists and are attached to various, formally independent, organizations. The not-for-profit organization Initiative Neue Soziale Marktwirtschaft (INSM), which is (according its own web pages) financed by "…the employers' associations of the metal and electrical industries" (INSM, 2015) and which is often criticized for disseminating misleading information (e.g. Morris, 2013 or Kemfert, 2013), is one example.

Ideological opponents

Additionally, Energiewende is criticized by neoliberals who dislike the non-market form of RES support (see Lauber & Jacobsson, 2015) and by far-right wing conservatives who mind the "green" ideas, as such (see Kemfert, 2013). At the political level, the FDP represents the more significant, neoliberal, sort of opposition; parts of the CDU/CSU and a very small part of the SPD also tend to regard Energiewende in this way. (Kemfert & Horne, 2013, p. 5)

Local opposition

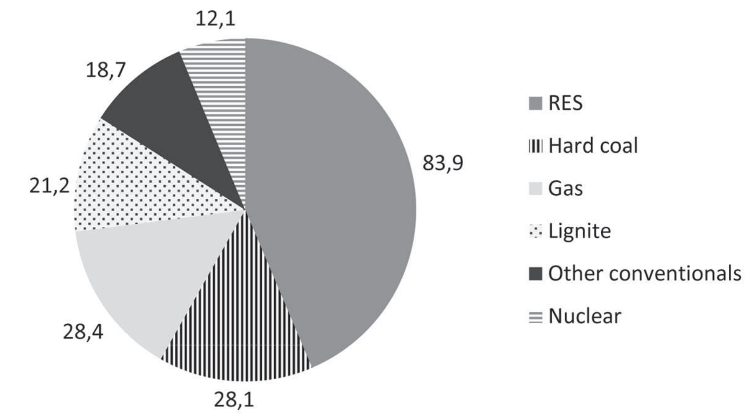
The initiatives by local opposition should not be left off of the list of transformation opponents. There are tens if not hundreds of them. They do not oppose Energiewende as such, but rather specific projects inherent to the transmission grid or wind farms. In this way they indirectly support the interests of the previously mentioned critics. (Kemfert & Horne, 2013, p. 6–7)

1.5 Technical indicators

In this chapter we focus on the influence of Energiewende on the shape of the power sector. We are interested in the energy mix transformation, i.e. individual sources used to produce electricity, as well as energy efficiency and energy savings in general. At the end we deal with some indicators of the volume of greenhouse gas emissions, the German import and export position, and network stability.

The following graphs summarize the total installed capacity, installed capacity in RES, total electricity production in Germany and electricity production from specific RES. This information can provide us with a general idea about the situation in Germany.

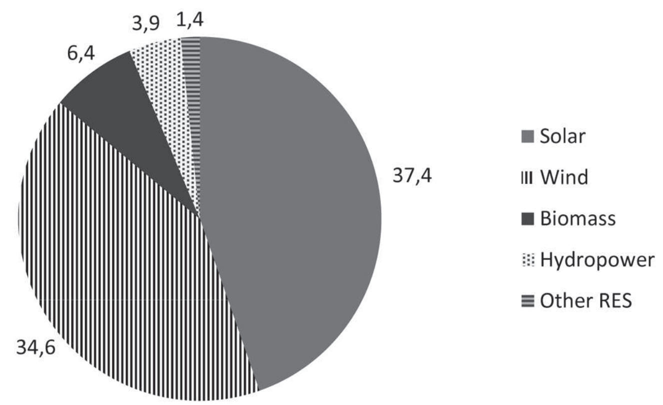
Fig. 2: Installed capacity in GW in Germany (192 GW total, 7/2014)



Source: (The Regulatory Assistance Project, 2015, p. 13)

The first graph highlights the significant share of the installed capacity of renewable sources. Lignite, hard coal and gas play significantly smaller roles, and the atom represents about ten percent of the total installed capacity.

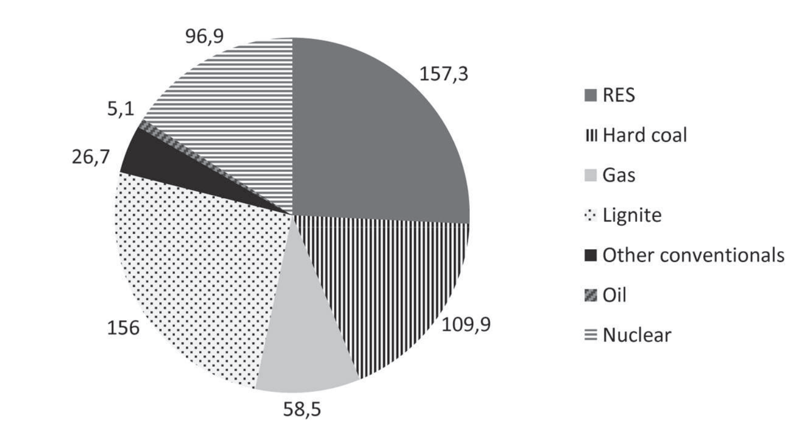
Fig. 3: Installed RES capacity in Germany (in GW, 7/2014)



Source: (The Regulatory Assistance Project, 2015, p. 13)

In terms of RES capacity, PVE facilities and wind power plants produce the lion's share. This is due to major support for these sources within the StrEG and, later, the EEG. Hydraulic power sources remain practically unchanged in Germany due to the total exhaustion of potential sites. The share of biomass has slowly been growing, and its considerable advantage lies in its predictability as well as its benefits to local agriculture.

Fig. 4: Electricity production in 2014 in Germany (TWh, preliminary data)



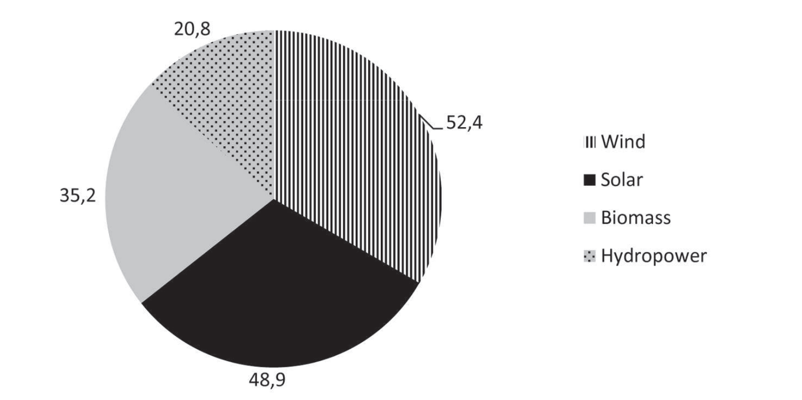
Source: (The Regulatory Assistance Project, 2015, p. 14)

The graph showing electricity production contrasts with the graph showing installed capacity. The difference is, of course, caused by the utilization of the particular sources; while the nuclear power plants work up to 90 % of the time, the utilization of wind sources, for example, is between 20–40 %, depending on location.

About one quarter of the production is from renewable sources. Practically the same amount of electricity is supplied from brown coal power plants. Although it is clear from the previous graphs that the total installed capacity of lignite is smaller than that of the hard coal, the cheaper lignite is more competitive. Hard coal and nuclear power plants follow. Despite the fast

growing share of RES, it is obvious that fossil fuels (hard coal and lignite) still provide the bulk of electricity produced in Germany.

Fig. 5: Electricity production from RES in 2014 (TWh, preliminary data, rounded)



Source: (The Regulatory Assistance Project, 2015, p. 14)

The above mentioned utilization also influences the production of a particular RES. It is distributed more equally than it may appear based on the installed capacities. The different capacity factor, i.e. the comparison of the real amount of the electricity produced with the potentially produced amount when operating the source at its maximum capacity for the entire year, plays a role here. Nevertheless, the presented graphs have only limited informative value, mainly because of their statistical nature. Therefore we examine the individual sources in more detail in the following chapters. At the same time we will try to more accurately describe the development trends over time.

1.5.1 Renewable energy sources

Renewable energy sources are the core of Energiewende. As nearly zero-emission sources, they are supposed to replace fossil fuels to a large extent and thereby reduce greenhouse gas emissions, limit local pollution, decrease German dependence on imports, and strengthen the position of German exporters of high added value industrial products.

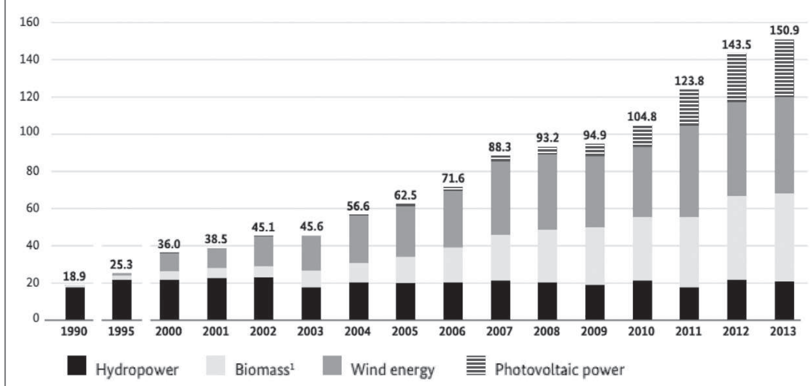
Legislatively, RES have been handled by the EEG since March 2000, as well as by the Renewable Energy Heat Act (Erneuebare-Energien-Wärmegesetz, EEWärmeG) and its investment incentive program. The support programs for transportation and the development of electromobility (such as the National Electromobility Development Plan) are also worth mentioning. A wider framework for the German objectives is then provided by the EU directive 2009/28/EC “On the Promotion of the Use of Energy from Renewable Sources”. It requires Germany to reach an 18 % share of RES in gross energy consumption by 2020. (BMWi, 2014, p. 6)

The BMWi statistics for 2013 define the share of RES in the gross final energy consumption as 12 % and 25.3 % of gross electricity consumption (the current estimated value for 2014 is 26.2 %). The RES share in the final energy consumption for heating and cooling is 9.1%, in transport it is 10.4 %. (BMWi, 2014, p. 7) An interesting although not representative fact is that the RES reached the highest share of consumption on the night of 11 May 2014 when it accounted for 80 % of total demand. (The Regulatory Assistance Project, 2015, p. 14)

The development trend over recent years is as follows: The fastest pace of growth in RES was seen in photovoltaic panels (up by 11 GW between 2011–2013) and wind energy (up by 5.6 GW between 2011–2013). This was due to the amount of financial support provided by the EEG and also to the earlier depletion of the water sources. Less frequently discussed is the high share of biomass whose significant value lies in its predictability and stability of production.

The construction of photovoltaic and wind power plants culminated in 2012, and in 2013 the pace of construction significantly declined. The investment level in PVE also significantly decreased to less than half of what it had been the previous year (from €11.17 billion to €4.24 billion), and the installation of new panels decreased nearly by one third. (O’Sullivan, Edler, Bickel, Lehr, Peter, & Sakowski, 2014, p. 4.) This development

Fig. 6: Development of renewables-based electricity generation in Germany (Gross electricity generation, TWh)



Geothermal electricity generation is not shown due to the small quantities involved.

1 including solid and liquid biomass, biogas including biomethane, sewage gas, landfill gas and the biogenic fraction of waste; also including sewage sludge as of 2013

Source: (BMWi, 2014, p. 10)

was a result of the purchase price reduction and of the more stringent restrictions on connecting photovoltaics to the grid. (Statistisches Bundesamt, 2014)

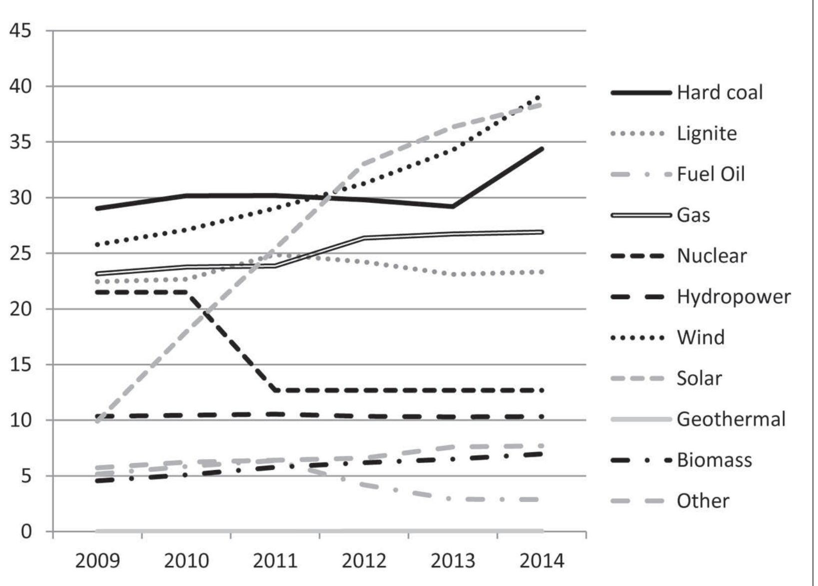
Germany also has one of the highest shares of wind power in the energy mix among EU countries. For example, in 2013, investments in both onshore and offshore farms increased by €3.16 billion over the previous year. (O’Sullivan, Edler, Bickel, Lehr, Peter, & Sakowski, 2014, p. 4) The construction of the biggest offshore wind farm in Germany, BARD 1, was also completed. (Fraunhofer IWES, p. 7)

1.5.2 Conventional sources

In view of the climate goals, the increase in the share of both hard coal (from 117 TWh in 2010 to 121.7 TWh in 2013) and lignite (from 145.9 TWh in 2010 to 160.9 TWh in 2013) in the production of electric energy is, to certain extent, paradoxical.

This fact is often associated with the need to replace the offline nuclear sources with other power plants. However the situation is more complicated. With respect to the annual aggregate data, it is evident that the decrease in nuclear production is more than compensated for by the production of the renewables. This applies less to short term production, though, when a momentary drop in RES production is actually augmented by an increase in fossil source production. In this situation, coal sources (mainly hard coal) provide flexibility. But this is not the only reason why coal remains important. The currently low coal prices on the European market thus result in the cheap electricity produced in the German coal-fired power plants. Coal, in combination with the volatile RES, also contributes to the continuously growing German export of the electricity.

Fig. 7: Production capacities in GW, 2009–2014



Source: BMWi, 2014f, p. 22

The share of nuclear energy in the consumption of electricity decreased in 2010–2013 from 10.8 % to 7.7 %. The remainder of the power plants will be shut down by 2022. (BMWi, 2014f,

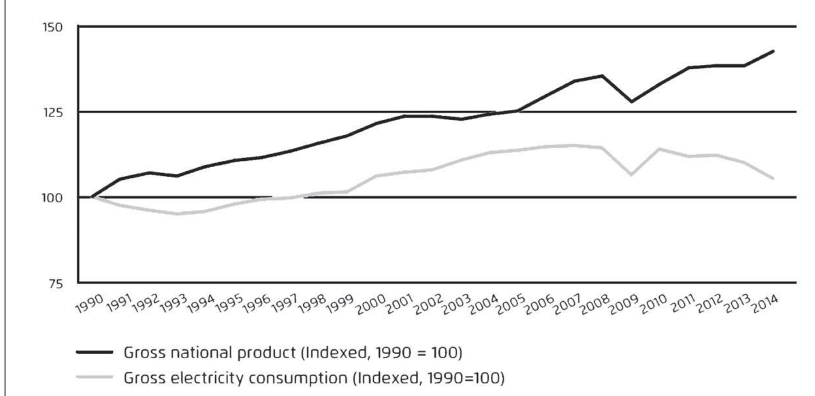
p. 4) Because of the social consensus, a change in this decision is not expected.

According the latest data from July 2014, 6,558 MW of new thermal power stations were under construction with an expected completion date of 2016, while 11,251 MW of production capacity will be shut down by 2018. (The Regulatory Assistance Project, 2015, p. 15)

1.5.3 Electricity consumption and energy efficiency

One of Germany's distinctive objectives is the increase in energy efficiency and the reduction in primary energy consumption by 20 % by 2020 and by 50 % by 2050, both in reference to the year 2008. At the same time, Germany has targeted a reduction in gross electricity consumption by 10 % by 2020 and by 25 % by 2050. These goals are supported at the EU level by the Energy Efficiency Directive 2012/27/EU, and at the national level by the National Energy Efficiency Action Plan (Nationaler Aktionsplan Energieeffizienz).

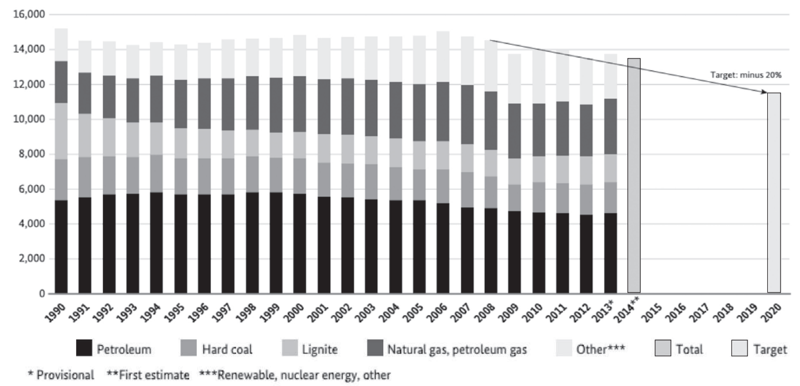
Fig. 8: Energy productivity in Germany, 1990–2013



Source: (The Regulatory Assistance Project, 2015, p. 33)

As is clear from the graph, German electricity consumption has stabilized during the last decade (for energy consumption see the graph). Even though the values are not sufficient to fulfill the goals set out in EW, and the German authorities continue to plead for a more intensive advancement, it still reflects a significant improvement. Germany is a large and highly industrialized country, and the separation of economic growth from electricity consumption is unique in comparison with similar states. At the same time, it is evident that the stable rates of electricity consumption are not a result of the economic crisis; the German GDP is growing and the economy is one of the best in Europe. The savings are clearly due to the active effort of the society and not a consequence of external factors.

Fig. 9: Development of primary energy consumption by energy source (adjusted figures in petajoules)



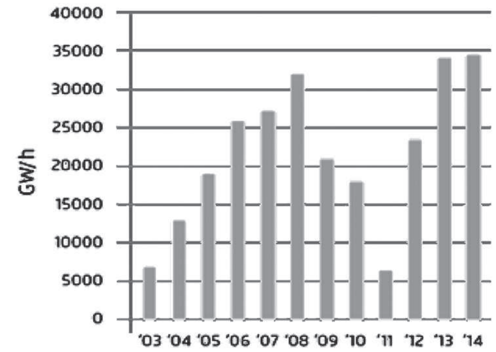
Source (BMWi, 2014)

1.5.4 Import and export of electricity

Germany has long been distinctive among European electricity exporters, both in terms of total export and ratio of domestic production to the total trade balance. This has been disrupted by two factors in the last decade: first by the decrease in demand for electricity resulting from the 2008 economic crisis, and second, because of the shut-down of some of the nuclear power plants

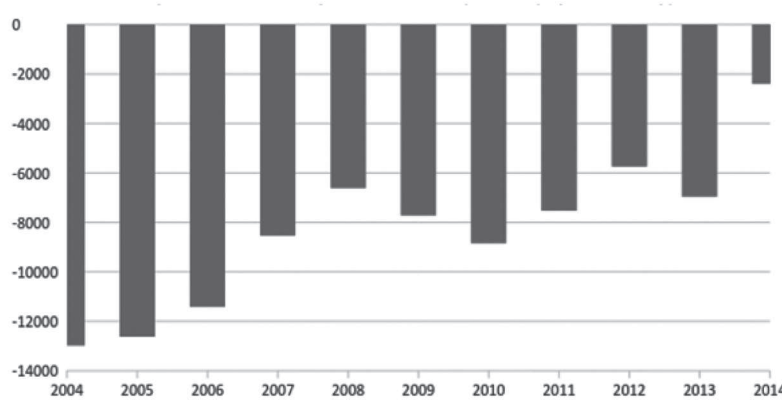
in 2011. Nevertheless, as the following graph shows, German net export has continued to show steady growth over the last few years.

Fig. 10: Net export of electricity, physical flows



Source: (The Regulatory Assistance Project, 2015, p. 17)

Fig. 11: Net electricity import from CR to Germany (in GWh, physical flows)

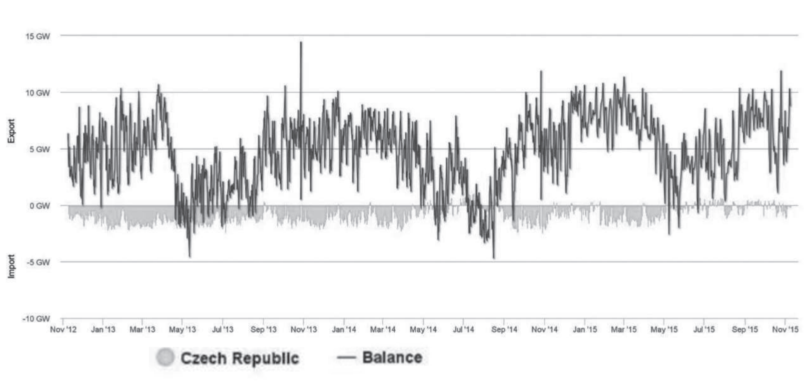


Source: (ENTSO-E, 2015)

The graph summarizes the trade balance between the Czech Republic and Germany. It is clear that the CR exports significant volumes of electricity to Germany but this trend has significantly weakened in recent years.

Nevertheless both of the graphs above work only with the physical flows of electricity.[15] The graph below summarizes the total balance of Germany (purple curve) and its position in relation to the Czech Republic (green curve), and provides an overview of the trade flows for the last three years.

Fig. 12: Power imports/exports



Source (Agora Energiewende, 2015)

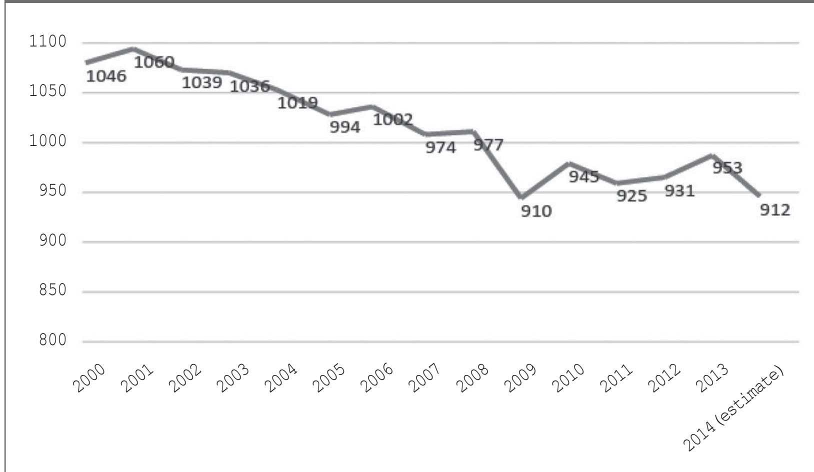
1.5.5 Greenhouse gas emissions

The volume of greenhouse gases produced in Germany is currently stagnate or shows only slight growth. The biggest greenhouse gas producer is the energy sector. (BMWi, 2014h, p. 24) This is caused by the continued strong position of coal-fired power plants which are, due to the low price of coal, very profitable.

As shown in the graph, the data for the year 2014 projected a decrease in emissions.

[15] Although in terms of physical nature of this commodity, the physical flows do not have to necessarily correspond with the contractual ones. In Germany this is an especially sensitive issue which we will deal with, for the sake of more clarity, in chapter 5.1.1.

Fig. 13: Greenhouse gas emissions, Germany (in millions of tons of CO_2 Equivalent)



Source: (Umwelt Bundesamt, 2015)

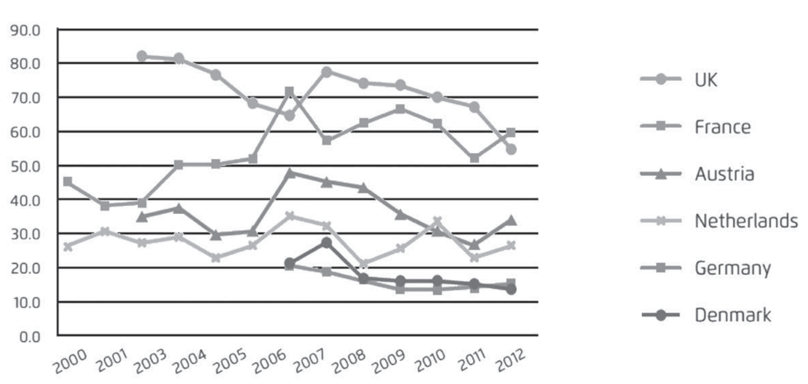
1.5.6 Grid stability and security of supply

Non-dispatchable RES (photovoltaic and wind farms) as well as nuclear power plant shut-downs pose an increased problem for the stability of the transmission grid. Nevertheless the available data show that the German network is dealing with this issue adequately. This is confirmed by the following analysis.

The extent of RES development in Germany is currently possible because of the traditionally high endurance of a German grid which was constructed to have very high capacity reserves. The grid is therefore able to incorporate a tens of per cents share of RES, which, until recently, was unimaginable.

With the exception of the thirty or so major wind and solar power plants, all of the renewables facilities (ca. 840 with more than 10 MW capacity) are connected to the generally highly stable German distribution network (up to 110 kV). The SAIDI Index (System Average Interruption Duration Index) indicates the system average interruption duration of an electricity supply and is an important indicator of distribution grid reliability. In 2013, the SAIDI Index value in Germany was 15.32 minutes. This was less than the previous year (15.91 minutes in 2012), approximately the same level as in 2011 (15.31 minutes), and significantly less than in 2006–2011 (average 17.09 minutes). The German Bundesnetzagentur notes that Energiewende and the related decentralization of electricity production have had no influence on the quality of the electricity supply. (Bundesnetzagentur, 2015, pages 51, 53)

Fig. 14: SAIDI – unplanned outages, emergency situations not included (minutes lost/per consumer)



Source: (The Regulatory Assistance Project, 2015, p. 35)

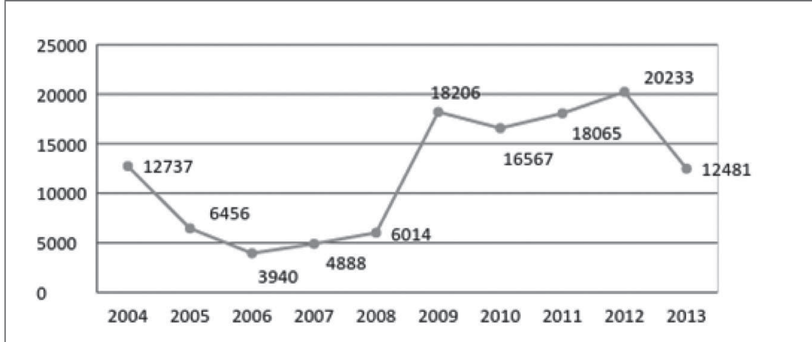
When electricity production from RES exceeds the capacity of the distribution network, it is not possible to utilize the electricity produced even when applying the balance measures. The excess electricity is transformed to a higher voltage (220 or 380 kV) and fed into the transmission network where it becomes the part of German-wide or cross-border flows.

If an imbalance occurs at the transmission network level, the TSO may connect the reserve output capacities which provide the network with the reserve energy. This can be both positive (supplied in the case of shortage) and negative (reduced in the case of surplus).

It is possible, then, to monitor network stability using the three indicators: the number of times reserves are activated, the amount of contracted reserve capacity[16] and the total consumption of the reserve capacity. As a general rule, the fewer the activations there are and the less energy is contracted and used for balancing the network, the more stable the network is. This is because market participants comply with their commitments without production or consumption deviations. Also, with fewer activations and a lower amount of contracted energy, less reserve capacity is necessary to maintain readiness and fewer expenses are necessary for network operation.

As for the influence of RES on transmission network stability, the reserve capacity in the form of so-called minute reserves,[17] mainly used for the balancing of RES, is particularly important.

Fig. 15: Frequency of use of minute reserve (number of dispatch instructions)



Source: (Bundesnetzagentur, 2015, p. 88)

[16] In the German system, particular TSOs project the amount of reserve energy needed in a given period and contract the reserve capacity suppliers accordingly. These services (reserve capacity available) are added into the costs of the network operator and therefore are passed on to the end consumer. The regulatory energy itself which is finally requested by the TSOs from the providers is then payed for in arrears to the originator of the deviation.

[17] The reserve capacity is divided according to the source of the primary control reserve (0–30 seconds), secondary control reserve (30 and more seconds) and the minute reserve (5, 15, 30 minutes).

The number of minute reserve activations does not follow any clear trend. Whereas in the period 2006–2012 there was, on average, a dramatic increase in requests which can be attributed to a large extent to the connection of non-regulated RES, in 2013 there was a sudden year-on-year drop of about 38 % from the 2004 values, or alternatively, to the average of the years 2008 and 2009. This drop can be explained by the great changes in the balancing management. In 2010, a scheme for grid control cooperation between all four German TSOs was completed. It had the following purpose (Bundesnetzagentur, 2015, p. 84):

- Sharing of the secondary and minute reserve capacities for all of Germany
- Creation of a common German market with the secondary and minute reserves
- Compensation for the imbalances between the particular control areas and for the connection of the reserve capacity made only for the total (final) imbalances across the system

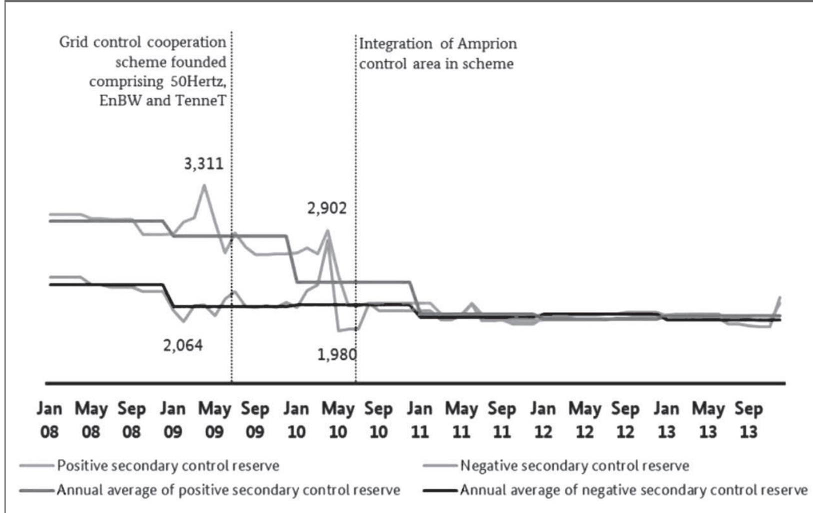
In addition, the German Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur) significantly simplified market access for the reserve capacity, thereby resulting in an increase in competition and a decrease in reserve capacity prices. Specifically, this measure reduced the minimal capacity offered, shortened the contract duration and introduced the opportunity for a single investment body to participate on the market with primary, secondary and minute reserves. (Bundesnetzagentur, 2015, p. 84)

Furthermore, a significant increase in intra-day market trading also influences the total need for the reserve capacity. This, together with international trade, is the cheapest balancing tool.[18] Between the years 2011 and 2012, the completed intra-day transactions increased from 363,000 to almost 677,000; in 2013, it was nearly as high as 1,287,000. (Bundesnetzagentur, 2015, p. 94) Another significant increase can be expected after the introduction of the 15 minute products on the intra-day market on 9 December 2014. The deliveries for such a short interval are an ideal tool for the balancing of the non-dispatchable sources.

These measures significantly influenced the indicators which directly affect end prices, namely, total reserve capacity contracted and total reserve capacity consumed. Whereas the contracted secondary reserve shows a falling long-term trend, in recent years the amount of the contracted minute reserve has been characterized instead by volatility. This volatility is, according to the Bundesnetzagentur, a direct consequence of the greater implementation of RES in electricity production.

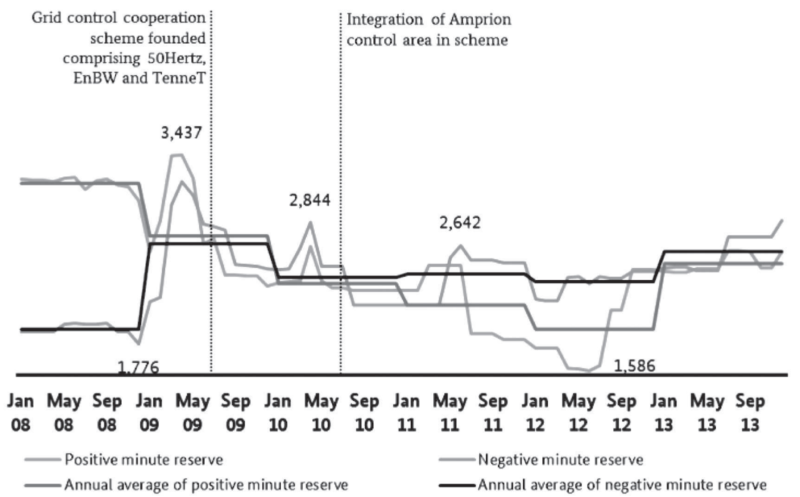
[18] Instead of failing to produce/consume and subsequently to pay a deviation fee the missing/excess electricity is purchased/sold on the short term market to a counterpart having an opposite problem. In a sufficiently large and interconnected market, this way of the network balancing significantly reduces the need for secondary control and reserve.

Fig. 16: Contracted secondary reserve, in MW



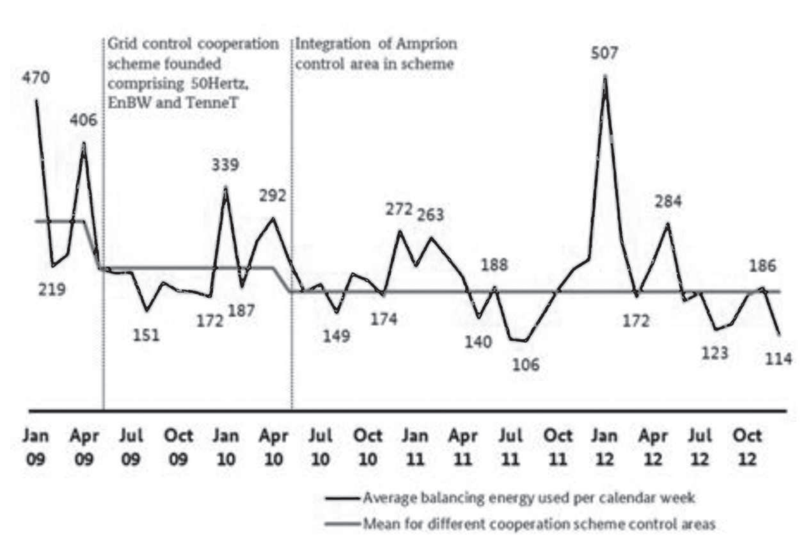
Source: (Bundesnetzagentur, 2015, p. 85)

Fig. 17: Contracted minute reserve, in MW



Source: (Bundesnetzagentur, 2015, p. 86)

Fig. 18: Average balancing energy used, in MWh



Source: (Bundesnetzagentur, 2015, p. 92)

The volatility also goes hand in hand with reserve capacity consumption used for network stabilization during periods of imbalance. Apart from the extreme situation in February 2012, the fluctuations in regulation energy consumption are not different from those in the 2009–2010 period.

Since network instability is reflected through the need for reserve capacity in the end prices, the crucial fact is that the values of the consumed reserve capacity decrease despite the rapidly growing share of RES: between the years 2009 and 2013 the total consumed regulation energy in Germany decreased by 37 %, from 285 MWh/month to 180 MWh/month.

For comparison, in the same period there was an increase of the installed capacity of non-dispatchable RES (photovoltaic and wind power plants) from 36 GW to 70 GW (94 %), and an increase in the production of these sources from 45 TWh to 83 TWh (84 %).

Tab. 3: Non-dispatchable RES vs reserve capacity consumed

	2009	2013	Balance
PVE and wind installed electrical generation capacity (GW)	36	70	+94 %
PVE and wind based electricity generation (TWh)	45	83	+84 %
Reserve capacity consumption (MWh/month)	285	180	-37 %

Source: (Bundesnetzagentur, 2015, pages 32, 92)

The consequences for EW are obvious. The robust network and good market organization help Germany to manage the implementation of the renewable sources in tens of per cent of the consumption, not only without the need of large investments into the storage capacities but also while maintaining a reduced reserve capacity demand. A no less important trend is the increasing volatility of the minute reserve which will further complicate usage prediction and therefore will also increase the uncertainty regarding its financial returns.

1.6 Financial indicators

Energiewende is an extremely financially demanding process. The German government estimates its total costs at €550 billion by 2050. The annual investments of €15 billion, or 0.5 % of GDP, are expected. (BMWi, 2012, p. 13) The costs of the network extension increase not only because of the RES subsidy and the nuclear sources shut-downs, but also due to the reconstruction of the energy sector. In 2012, the expenditures of the four German TSOs for network development were €1.152 billion, an increase of more than 305 million over 2011. The estimate for 2013 is €1.242 billion. (Bundesnetzagentur, 2014, p. 51) Nevertheless, the rate of construction does not correspond with the expectations and demands of EW, of which the most evident signal is the unscheduled electricity flows issue. (see chapter 5.1.1)

Whereas the costs of Energiewende are clear and immediate and the citizens and companies deal with them every day, the environmental, security and geopolitical benefits emerge only gradually. This existing imbalance can significantly influence the ability and willingness of the German public to continue with the implementation of the whole policy at the present pace.

Therefore, in this chapter we focus on the introduction of the relevant financial indicators, in particular the prices of electricity on the wholesale and retail markets and the RES subsidy calculation.

1.6.1 Electricity Prices

A detailed analysis of wholesale prices reveals two basic pieces of information. First, the wholesale price of electricity in Germany is among the lowest in Europe. (See graph below.)

Second, it falls continuously.

Nevertheless, these two pieces of information oversimplify the situation, however, and a more in depth explanation is needed here.

Primarily, there are two main factors which influence current market rates. The first is the strong surplus of production capac-

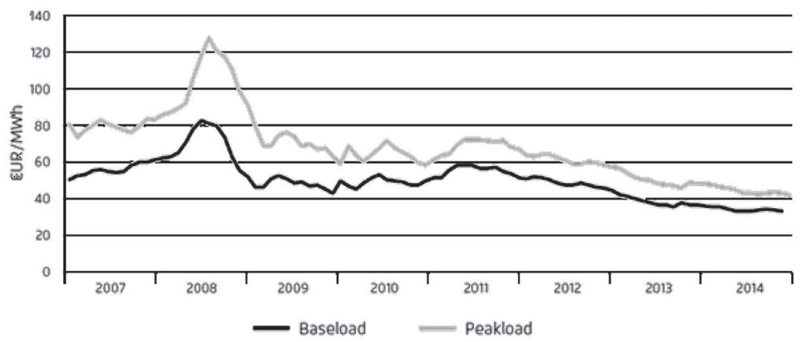
Fig. 19: Comparison of the average wholesale prices of electricity in the EU, Q4 2014 in eur/MWh.

Source: (European Commission, 2015, p. 10)

ities on the European and German markets. This is a result of the significant investments into both RES and, in particular, gas sources over the previous decade, as well as from the stagnation of electricity demand. The second factor is the falling price of coal caused by its replacement with shale gas in the USA.

Yet this reduction in the wholesale price of electricity does not manifest in the end prices for firms and households. These steadily rise. The reason for this is the increase in the regulated elements of prices: fees (mainly EEG fees for the RES subsidy), taxes and the costs of related services (e.g. grid services).

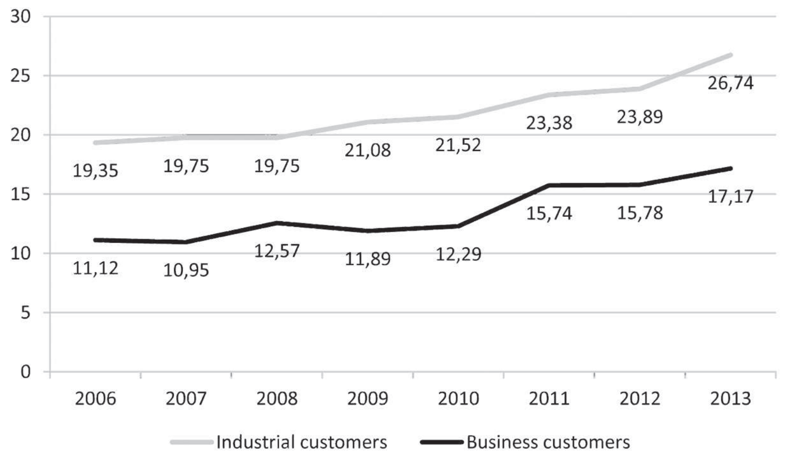
Fig. 20: Wholesale forward prices of electricity in Germany, 2007–2014



Source: (The Regulatory Assistance Project, 2015, p. 21)

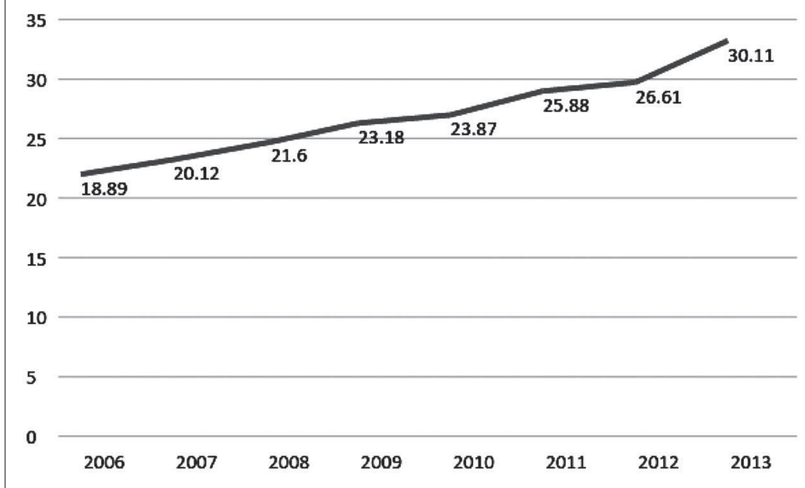
A major gap between the prices for corporations and households is also evident. This is caused by the German government's strategy to distribute the costs of the RES subsidy unevenly in order to alleviate the burden on corporations.

Fig. 21: Electricity prices for industrial and corporate consumers, 2006–2013, ct/kWh



Source: (BMWi, 2014, p. 170)

Fig. 22: Electricity prices for households, 2006–2013, ct/kWh

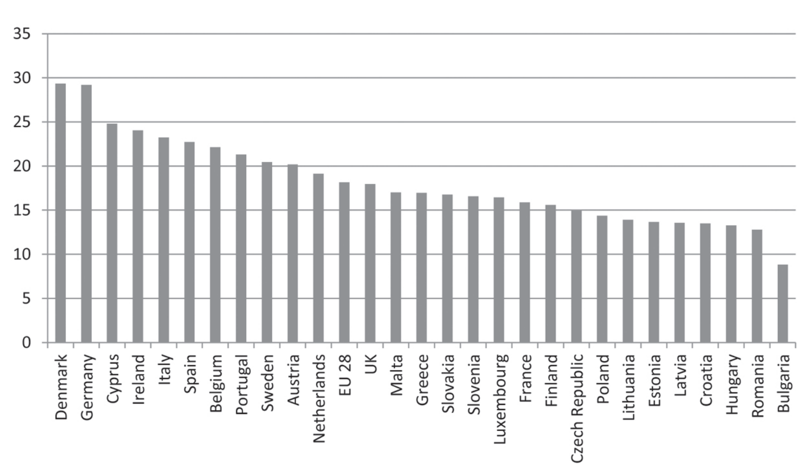


Source: (BMWi, 2014, p. 141)

Even companies do not bear the burden evenly. Prices are significantly lower for energy-intensive companies, which are, after fulfilling certain conditions, required to pay only a portion of the EEG fee.

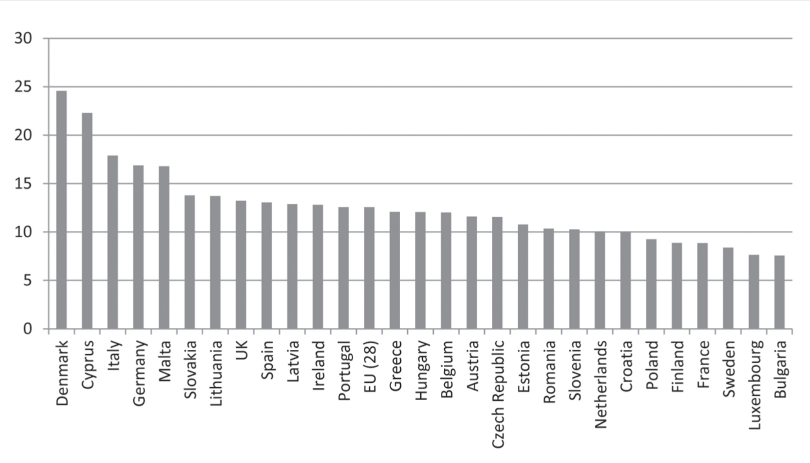
All in all, the situation in the Germany presents an interesting paradox. It combines one of the lowest wholesale prices of electricity in the EU with one of the highest prices for the consumer (the two graphs below show comparisons with the rest of the EU). The difference is then used mainly to cover the financial costs of EW, generally, and RES diffusion, specifically. This is possible thanks to the willingness of households to bear the financial burden and also because energy-intensive companies are provided with the RES fee relief and therefore their competitiveness on foreign markets is only partially hindered.

Fig. 23: EU household electricity prices, second half of 2013, ct/kWh



Source: (BMWi, 2015b, p. 181)

Fig. 24: EU electricity prices for industrial consumers, second half of 2013, ct/kWh



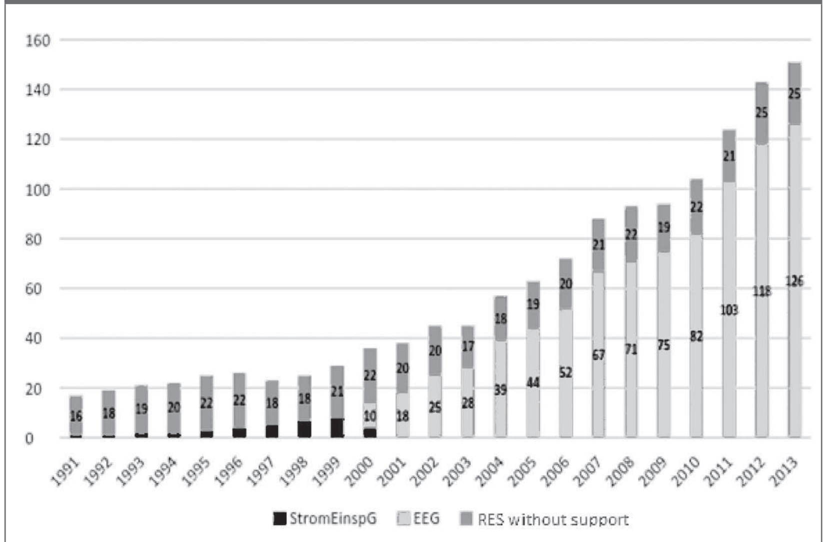
Source: BMWi, 2015b, p. 186)

1.6.2 RES financial subsidy schemes

On the previous pages we repeatedly touched on the issue of financial support for RES. It is a crucial tool for the development of these sources. At the same time this support is the object of both praise and criticism. Therefore we must analyze the entire policy in more detail.

Germany has subsidized RES through the Act on the Supply of Electricity from Renewable Energy Sources into the Grid (StrEG) since 1991. The act introduced the fixed feed-in tariffs targeted mainly at onshore wind farms. In April 2000, this act was replaced by the previously mentioned EEG. (BMWi, 2014, p. 28) The graph below shows the gradual redistribution of the financial support within the particular schemes.

Fig. 25: Electricity generation from renewable energy sources with and without remuneration under the StrEG and the EEG (TWh).



Source: BMWi

The EEG provides electricity producers with fixed purchase prices. Since 2009, this system has been supplemented with the option of market premiums in which the producer sells the electricity according to market conditions (without the buy-up obligation or fixed purchase price) and receives a certain financial bonus in addition to the market price. In 2013, this system was already prevalent and accounted for 54 % of all electricity included in the EEG.

Tab. 4: Electricity quantities and payments under the EEG

			2000	2002	2004	2006	2008	2010	2012	2013
Electricity generation	Hydropower	GWh	4,115	6,579	4,616	4,924	4,982	5,665	5,417	6,265
	Gases	GWh	–	–	2,589	2,789	2,208	1,963	1,769	1,776
	Biomass	GWh	586	2,442	5,241	10,902	18,947	25,155	34,321	36,258
	Geothermal energy	GWh	–	–	0	0	18	28	25	80
	Onshore wind energy	GWh	5,662	15,786	25,509	30,710	40,574	37,619	49,948	50,802
	Offshore wind energy	GWh	–	–	–	–	–	174	722	905
	Photovoltaic power plants	GWh	29	162	557	2,220	4,420	11,729	26,128	29,606
	Total amount of electricity within the EEG	GWh	10,391	24,970	38,511	51,545	71,148	82,331	118,330	125,693
	Of which: electricity with fixed purchase price	GWh	10,391	24,970	38,511	51,545	71,148	80,745	67,168	56,750
	Of which: directly traded electricity	GWh	–	–	–	–	–	1,586	51,163	68,943
	Gross electricity production from RES	GWh	36,036	45,120	56,632	71,638	93,247	104,810	143,463	150,878
Compensation	Hydropower	€million	298	477	338	367	379	421	427	512
	Gases	€million	–	–	182	196	156	83	52	58
	Biomass	€million	55	232	509	1,337	2,699	4,240	6,261	6,784
	Geothermal energy	€million	–	–	0	0	0.003	0.006	0.006	0.019
	Onshore wind energy	€million	515	1,435	2,301	2,734	3,561	3,316	4,895	4,866
	Offshore wind energy	€million	–	–	–	–	–	26	119	152
	Photovoltaic power plants	€million	15	82	283	1,177	2,219	5,090	9,202	9,476
	Total payments EEG	€million	883	2,225	3,611	5,810	9,016	13,182	20,962	21,869
	Of which: fixed purchase prices	€million	883	2,225	3,611	5,810	9,016	13,182	15,416	13,691
	Of which: market premiums or flexible premiums.	€million	–	–	–	–	–	–	5,546	8,178
	Average EEG compensation rate	Ct/kWh	8.5	8.9	9.4	11.3	12.7	16.3	18.2	17.9

Source: (BMWi, 2014, p. 29)

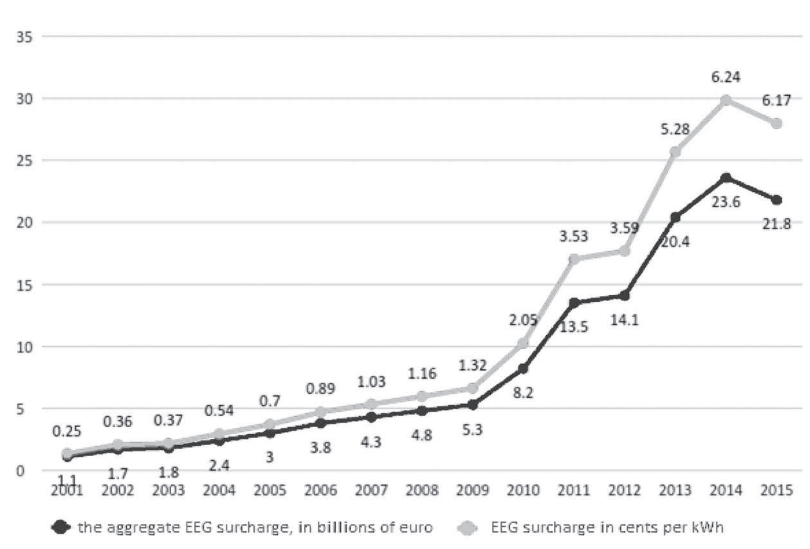
The growing share of RES influenced the amount of the subsidy. Whereas in 2000, the combined subsidy from the StromEinspF and the EEG totaled about €1.2 billion, by 2014 it had already grown to €22 billion. The reason for this was the dramatic growth of the installed capacity and therefore also the growth in both production and subsidy.

The aggregate EEG surcharge for 2015 is calculated at €21.8 billion, the EEG surcharge for 2015 is 6.17 cents for kWh.

Interestingly, there is an expected decrease in total support for 2015. This is the result of legislative reforms (mainly the

EEG) and it is a strong argument in favour of the sustainability of Energiewende. This is shown in more detail in the graph below where the blue curve shows the aggregate EEG surcharge and the orange curve shows EEG surcharge in cents per kWh. EEG payments should not be misunderstood as the costs of the EEG; the proceeds from selling electricity on the electricity exchange must be deducted from the EEG payments. (BMWi, 2014, p. 27)

Fig. 26: Development of the EEG surcharge



Source: (BMWi, 2014, p. 31)

1.7 Public support for Energiewende

Energiewende is also unique for one more reason. In the European context, it is an almost unprecedented, society-wide project on which there is agreement (more or less, of course) by individual segments of society, the political elite and the corporate sector.

Public opinion surveys show that the population considers itself to be burdened with EW implementation, and up to 70 % expect a further rise in electricity prices. (BDEW, 2014) Twenty-three percent of respondents support a €5 per month increase, 31 % support a €10 per month increase, and only 23 % are against any increase. (Scholz, et al.)

The public opinion surveys generally show a high degree of support for EW by the population; it is 89 %. (BDEW, 2014) Forty-six percent of the population is aware of the need to implement EW measures, for example the expansion of high voltage networks. (IfD Allensbach, 2013) The role of RES within EW is perceived positively by most of the population, but only 44 % consider the RES payments to be set appropriately. (Scholz, et al.) Twenty-two percent of the population is concerned about electricity supply emergencies, and 18 % consider it possible that electricity outages will occur. (Wirtschafts Woche, 2014)

Therefore, it seems that German society is critical of the individual aspects of Energiewende but consider the concept as a whole to be beneficial. They are also willing to support it.

Here we would expect that the most striking problem with the acceptance of EW by the general public to be the high electricity prices. But it should be noted that because of the relatively high purchasing power of the German population, and because of the energy efficiency of German homes, electricity expenditures are at a tolerable level (approximately 2.5 % of the household income). This means that Germans pay the same now as they did during the 1980s (although in the meantime these costs have decreased to under 2 %). (Graichen, 2014, p. 5) These expenses may still increase, of course, but because the 2014 EEG reform reduced the RES subsidy, no dramatic change is expected. In the other words, the costs of electricity are, for German households, a less serious problem than the pure figures may indicate.

Of course, the numbers can only be estimated because the consumer price of electricity is based on the different tariff levels which are based consumption. However, according to the BMWi, the average price of electricity for a household in 2014 was 29.1 cents/kWh. (BMWi, 2014, p. 32) The Czech household payed just over 4 Kc/kWh for mid-level consumption, varying according the supplier.[19] Again, it can generally be stated that the German price is twice as much as the Czech price. Nevertheless, it should be also added that German incomes are about three times higher than those in the Czech Republic.[20] From this perspective, German electricity prices are comparatively cheaper than Czech electricity prices.

Based on this state of affairs, it is unlikely that any pressure to radically change Energiewende will arise.

[19] For more details regarding the electricity prices see (TZB-info, 2015).
[20] For more details regarding the incomes in the individual countries see (Eurostat, 2015)

2. ECONOMY AND INFLUENCE OF RENEWABLE SOURCES ON ELECTRICITY PRODUCTION AND TRADE

The increasing share of renewables in electricity production is the most important change brought about by Energiewende in the German energy sector. Renewable sources differ from conventional sources (fossil fuels and nuclear energy) in several ways.

First, renewables are less controllable and predictable than conventional sources. Wind and solar energy production is determined by current weather conditions. These sources are volatile (e.g. the difference in production of photovoltaic plants during night and day) and this volatility brings a certain degree of uncertainty into the planning process (due to the accuracy of weather forecast models). The second characteristic feature is the nature of its operating economy. There are no fuel requirements for renewable sources (with the exception of biomass) and installation costs are artificially reduced through public financial support. It would be a mistake to consider RES merely as another diversifying source in the German energy mix; RES capacities significantly change the way electricity is produced and traded.

Other goals and instruments of EW do not have such great impact. In comparison with RES, nuclear phase out, the increase of energy efficiency and the reduction of emissions have only limited impacts on the German energy system.