Challenges and Opportunities of a Sustainable Energy Supply in a United Germany

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1. Background

Germany encountered considerable challenges, but also opportunities to establish a sustainable energy supply system after the unification of the country in 1991. Other countries such as Korea can profit from these experiences in case of an own unification+.

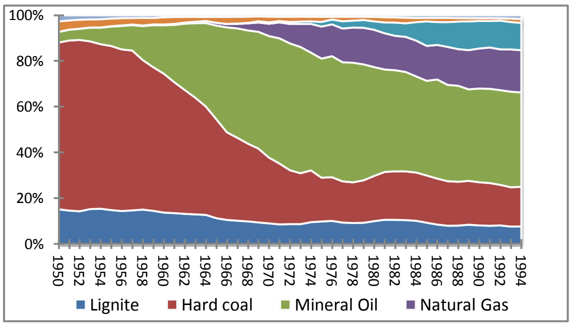
Against this background, Section 2 of the paper describes the most important framework conditions of energy policy in Germany, namely the development of the structure of energy carriers in Germany before and after the reunification and the energy political objectives of German government (energy-political triangle). Section 3 analyzes the challenges and opportunities in organizing a sustainable national energy supply in Germany after the reunification. The most important related developments in Germany after the reunification are liberalizing the domestic markets for grid-bound energy carriers and implementing the energy turnaround until 2050. A summary concludes the paper (Section 4).

2. Framework conditions of the energy policy in Germany

The most important framework conditions of energy policy in Germany after the reunification are (a) the development of the structure of energy carriers in Germany before and (b) the energy political objectives of German government (energy-political triangle), namely economic aspects, aspects of the energy security, and ecological aspects.

As in every economy, the energy structure and finally energy policy is determined by the domestic energy reserves. Except hard coal and lignite, Germany is short of domestic fossil energy reserves. About 97% of Germany's oil has to be imported. The history of the energy mix in West-Germany reflects this (Figure 1).

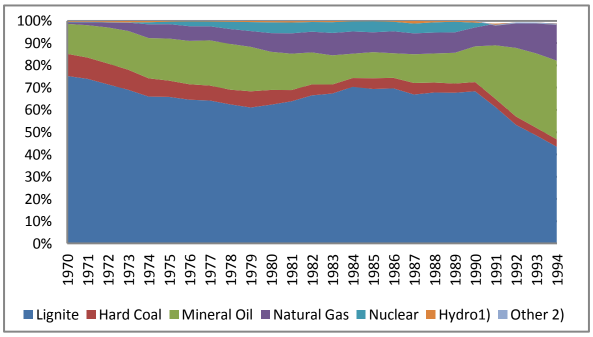
Figure 1:
Structure of Primary Energy Consumption
(West Germany, 1950-1994 in %)



Source: Arbeitsgemeinschaft Energiebilanzen (diff. years). 1) incl. export trading balance - power 2) other energy carriers: fire wood, fire peat, sludge, waste and other gases.

In the 1950's, almost 90% of primary energy supply was coal. Since the mid 1950's, the energy mix in Germany was turning away from hard coal and lignite towards mineral oil for transport and heating purposes until the 1970's. Since the late 1970's, nuclear energy capacities had been developed for power generation. Renewable energies reserves were largely untapped until the 1990's.

Figure 2:
Structure of Primary Energy Consumption
(East Germany, 1970-1994 in %)



Source: Arbeitsgemeinschaft Energiebilanzen (diff. years). 1) incl. Export trading balance power 2)) fire wood, fire peat, sludge, waste and other gases.

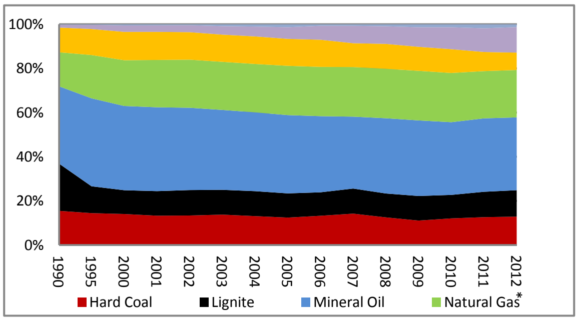
In East-Germany, the prevalence of coal remained until the German unification in 1991 (Figure 2).

+ This paper is based on a presentation of the author on the International Energy Conference "Energy Supply Options for the Unified Korean Peninsula: Lessons from Germany" on November 28, 2013 in Seoul, South Korea, organized by Konrad Adenauer Foundation, Yonsei-SERI EU Centre, Institute of East and West Studies (IEWS), Yonsei University, Oxford Institute for Energy Studies (OIES) and the University of Oxford.

About 80% of primary energy supply was coal. After the unification, especially transport related mineral oil demand and the share of natural gas increased.

Looking at the energy mix in Germany after the unification (Figure 3), in 2012, 12.9% of primary energy supply was hard coal, 12.0% lignite, 33.0% mineral oil, 21.5% natural gas, 7.9% nuclear energy, 11.6% renewables and 1.3 other energy carriers. Especially the installation of wind and solar energy increased the share of renewable energies in Germany.

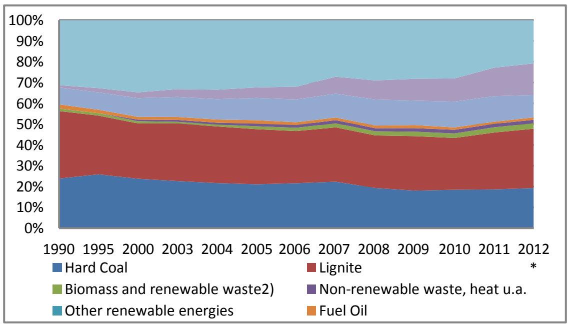
Figure 3:
Structure of Primary Energy Consumption
(Germany, overall federal area, 1990-2012 in %)



Source: Arbeitsgemeinschaft Energiebilanzen (diff. years). [1] Calculations based on the efficiency approach. [2] Other energy carriers: mine gas, non-renewable wastes and waste heat as well as power exchange balance. * Issue: 31/07/2013.

The energy turnaround in Germany is largely driven by changes in the fuel mix for power generation (Figure 4).

Figure 4:
Fuel structure for power generation
(Germany, overall federal area, 1990-2012 in %)



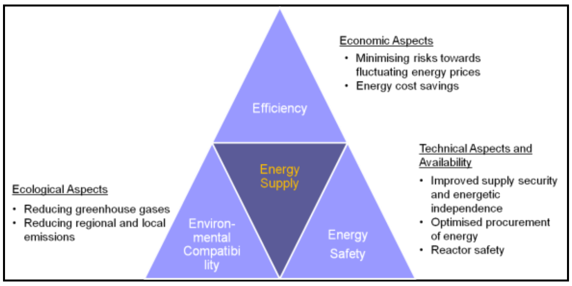
Source: Arbeitsgemeinschaft Energiebilanzen (diff. years). [1] Calculated on the basis of the efficiency approach [2] From 1995 to 1999 waste and other biomass; from 2000 to 2002 biomass and renewable waste, non-renewable waste, waste heat amongst others [3] Wind power from 1995 incl. photovoltaic. Since 2003 also including feeding-in of power based on regenerative energy carriers. * Issue: 31/07/2013.

In 2012, in Germany, there is still a considerable portion of hard coal (19.3%) and lignite (28.5%). However, since 2010, the share of nuclear energy is decreasing (20.8%) due to shut downs of nuclear power plants in favor of renewable energy sources (15.2%) supported by the Renewable Energy Act.

There is a backside of this development, though. Because of the low CO_2-certrificate prices on the energy stock exchange in Leipzig, the generation costs especially for lignite power plants are lower than gas fired power plants, so that many even new gas fired power generation facilities are not used.

German energy policy is lead by three energy policy objectives of energy supply: economic aspects, ecological aspects and technical and availability aspects largely attributed to energy security. Figure 5 shows this energy political triangle.

Figure 5:
Energy policy objectives of power supply



Source: Own depiction.

The economic aspects mainly include minimizing risks towards fluctuating energy prices and energy cost savings. This means, the power companies are aiming at reducing the financial risks of primary energy input prices as well as their own controllable power generation costs.

The ecological objectives are the reduction of greenhouse gases, mainly CO_2, as well as regional and local emissions such as SO_2 and NO_x. The technical and availability aspects include the improvement of supply security and energetic independence, optimized procurement of energy and reactor safety. These aspects mainly touch the reduction of physical primary energy input availability risks. To reduce these risks, inter alia, long-term delivery contracts are signed with Russian gas providers such as Gazprom or to ensure possible independence, alternative gas pipelines are planned such as the Nabucco pipeline from the Caspian Sea.

3. Challenges and opportunities in organizing a sustainable national energy supply in Germany after the reunification

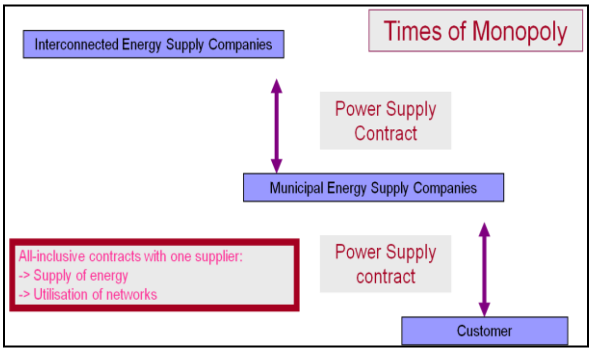
The most important developments in Germany related to the organization of a sustainable national energy supply in Germany after the reunification are (a) liberalizing the markets for grid-bound energy carriers and (b) implementing the energy turnaround.

3.1 Liberalization of the markets for grid-bound energy carriers

Until the mid 1990's Germany's energy market regulations still had been based on the German Energy Act from 1935 (Figure 6).

The customers had contracts with integrated power supply companies covering power generation, transmission and distribution in regional supply monopolies. These power companies had been seen as "natural monopolies", because the initial investments in power plants and transmission and distribution networks for newcomers on the market is prohibitively high and preventing them from entering the existing energy market.

Figure 6:
Energy Market Structure according to the EnWG (Energy Act) of 1935



Source: Sommer (2011).

This systems changed after the EU decided to liberalize the European markets for grid-bound energies similar to the North-American system and to strive for power tariff reductions through competition on the national energy markets.

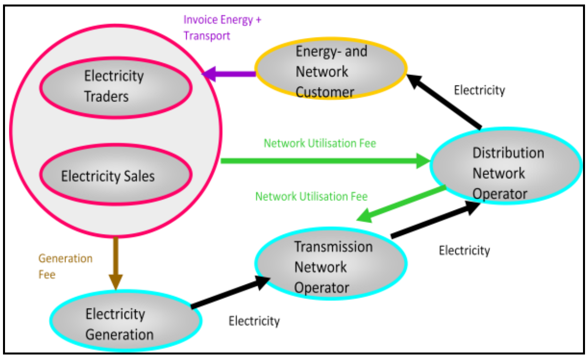
In 1996, the EU Commission issued the first EU-Directive for the liberalization of the electricity market, and 1998 the first EU-Directive for the liberalization of the gas market. Within two years, in 1998, Germany transferred the EU-Directive into German law (Energy Act of 1998) and liberalized the German electricity market. Now, every customer can chose from whom he purchases electricity and the electricity suppliers can sell their electricity outside their former monopoly region.

In 2003, there was a revision of the EU-Directives for the liberalization of the energy markets. Objective was to reduce the energy prices for customers through competition. Essential aspects were that the electricity and gas markets had to be opened up completely for all non-household customers until 1 July, 2004, at the latest, and for all customers starting from 1 July, 2007, at the latest. All EC-member states are obliged to name a regulatory body for the electricity-and gas market until the 1 July, 2004, who will issue the approvals for the grid utilization fee, amongst others. Subsequently, in Germany, the German Federal Net Agency was established. The integrated electricity and gas network operators were now committed to unbundle the network sections of their companies from the generating, procurement and sales sections.

In 2004, the German gas market was liberalized.

In 2005, the New Energy Act of 2005 transferred the EU-Directive from 2003 into German law. Figure 7 shows the German electricity market structure according to the Energy Act of 2005.

Figure 7:
German electricity market structure according to the Energy Act of 2005



Source: Sommer (2011).

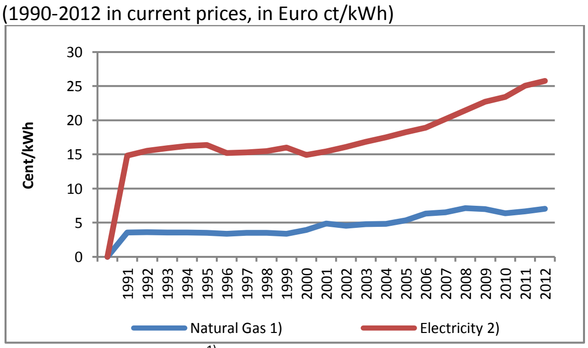
The final customers can freely chose their power suppliers. These can be the producers of electricity themselves of only electricity traders (such as Yellow Strom etc.) which buy the electricity from the power producers on the stock exchange and pay a network utilization fee to the network owners.

In 2009, there were new revision of the EU regulations (Third EU Energy Package). Main goals were

- Decoupling of electricity transmission and distribution through:
  - Separation of ownership,
  - Independent System Operators (ISOs), or
  - Independent Transmission Operators (ITOs).
- Improvements of customer rights (cost-free change of the gas or power supplier within three weeks).
- Installation of smart meters for 80% of the customers until 2020.
- Establishment of a right for basic power supply and protection of low-end customers.

The hopes for a substantial and sustainable decrease of energy prices through the market liberalization did only come true temporarily. As Figure 8 reveals, the prices for electricity and gas in Germany only decreased during the first few years of liberalization.

Figure 8:
Prices of electricity, oil and gas in Germany
(1990-2012 in current prices, in Euro ct/kWh)



Source: BMWT(2013). 1) Delivery of more than 1600 kWh per month, including all taxes and levies. 2) Delivery of 325 kWh per month, including all taxes and levies.

After 2000, the concentration of energy suppliers in Germany lead to an increase of energy prices and the lack of investments in the network in the beginning even caused problems regarding network stability and in larger areas electricity black-outs occurred.

3.2 Implementation of the energy turnaround

The nuclear disaster in Fukushima in 2011 lead to a massive change in German energy policy. The most important cornerstones and sectors of the energy transition were laid out in the so-called "cornerstone paper" of the Federal Government from 06/06/2011 (Regierung der Bundesrepublik Deutschland, 2011). Cornerstones of the energy turnaround are:

- A gradual shutdown of all nuclear power plants by the end of 2022 (eight nuclear power plants already had been shut down after the Fukushima incident and have not been taken back into operation).
- An acceleration of the fundamental restructuring of the energy supply.
- A gradual reduction of greenhouse gas emissions by 80-95 % by 2050.
- A rapid expansion of renewable energies, particularly wind energy and optimizing the interaction with conventional energy sources.

For the energy turnaround, different sectors were identified and measures envisaged.

a) Electricity and heat generation:

Market and system integration, including the improvement of the remuneration of offshore wind, hydro and geothermal power, compensation of emissions trading-related increases in electricity prices for energy-intensive companies, amendment to the planning law for repowering (wind).

Network expansion (mandatory and coordinated network expansion planning (under the Energy Act) for the major electricity transmission and gas transmission networks (10-year network development plans), improving the environment for the planning of low-loss high-voltage direct current lines (HVDC).

Promotion of storage technologies (exemption of new storage grid fees, increase in research funding).

Increased promotion of cogeneration especially for small operators.

Speedy completion of under construction of highly efficient conventional power plants.

b) Buildings:

ENEV 2012: 2020 step by step pre-accession of new standards in the future pan-European low-energy building standard. Promotion of refurbishing existing buildings.

c) Mobility: More climate-friendly mobility in the context of the development of a new fuel and Mobility Strategy.

d) Public procurement: More energy efficiency criteria.

e) Private consumption: Further development of European product standards.

Figure 9 shows the quantitative targets of the energy turnaround in Germany until 2050.

Figure 9:
“Energy Turnaround“ Targets in Germany

	Fixed targets	2020	2030	2050
C0	Reducing the greenhouse gas emission compared to 1990 by	40%	55%	80 – 95%
C1	Increasing the share of RE in the gross final energy consumption to	18%	30%	60%
C2	Increasing the share of RE in the gross electricity consumption to	35%	50%	80%
C3	Reducing the primary energy consumption compared to 2008 to	20%	-	50%
C4	Reducing the electricity consumption compared to 2008 by	10%	-	25%
C5	Increasing the energy efficiency compared to 2007 by	20%	-	-
C6	Reducing the heat requirement of buildings compared to 2008 by	20%	-	-
C7	Increasing the number of electric automobiles to	1 Mio.	6 Mio.	-
C8	Reducing the energy consumption (traffic sector) compared to 2008 by	10%	-	40%
N1	Increasing the installed performance of offshore wind to	-	25 GW	-
W1	Limiting the renewable energy act (RE)-apportionment to 3.5 cent/kWh			
	At present not completely defined targets			
C	Reducing primary energy requirement of buildings compared to 2008 by	-	-	~80%
C	Annual rate of building refurbishment of 2%	-	-	-
V	Additional building of secured fossil power plant performance	10 GW	-	-

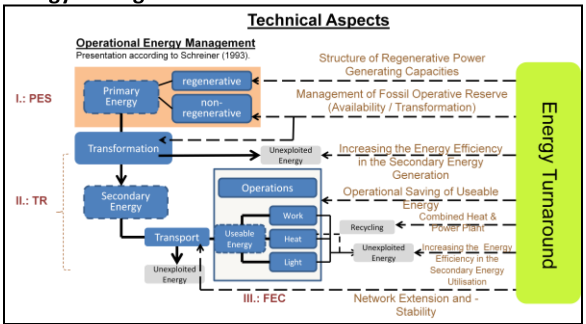
C = CO_2-targets N = Targets for networks W = Targets for Economic Efficiency V = Security of supply

Source: Weale (2013).

The energy turnaround has different effects on the company's energy management, both on the technical side as well as on the economic and ecological side. Based on the concept of an energy balance, these effects can be systematized (Figure 10).

In primary energy supply (PES), the energy turnaround has effects on the amount and structure of renewable power generation capacities, i.e. how much and which kind of energy (wind, solar etc.) will be used. The same is for the primary energy input for fossil power generation including the management of fossil operative reserve, if no sun is shining and no wind blowing (availability/amount of transformation).

Figure 10:
Technical “energy turnaround“ effects on the company energy management

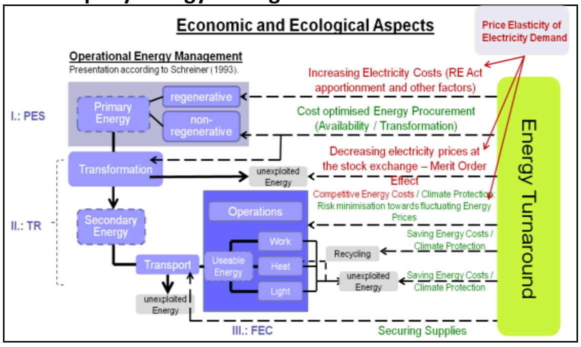


Source: Own depiction.

In the transformation sector (TR), there will be an increase of energy efficiency in the secondary energy generation, e.g. the use of CCGT (combined cycle gas turbines) technology. As for transmission and distribution, network extension e.g. with low-loss HVDC (High Voltage Direct Current) transmission technology and the preservation of network stability will be the main impact of the energy turnaround.

In the final energy consumption (FEC) of the companies, the operational saving of useable energy, e.g. with combined heat & power generation and the increase of energy efficiency in the secondary energy utilization will be the main tasks of the energy turnaround in Germany.

Figure 11:
Economic and ecological "energy turnaround" effects on the company energy management



Source: Own depiction.

Figure 11 shows the related Economic and ecological "energy turnaround" effects on the company energy management. Again, based on the concept of an energy balance, the economic and ecological effects of the energy turnaround on the company energy management can be systemized.

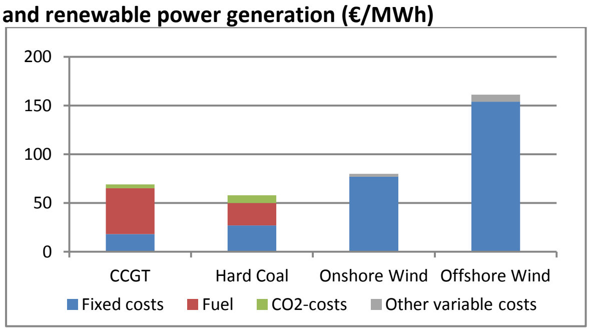
In primary energy supply (PES) and transformation (TR), there will be increasing electricity costs (due to the Renewable Energy Act apportionment and other factors). Hence, the companies especially have to take care for a cost optimized energy procurement or have to try to take advantage of the reductions of the renewable energy apportionment for electricity intensive companies. Security of electricity supplies may be in danger, if the additional power network will not be enlarged sufficiently quick.

In final energy consumption (FEC), electricity prices are increasing because of the growing renewable energy apportionment although there are decreasing electricity prices at the stock exchange (due to the Merit Order Effect 2, see below). Hence, companies have to take care for competitive energy costs and to save energy additional to possible investments in climate protection. Generally, they have to minimize their risks regarding fluctuating energy prices. As the price elasticity of energy demand (i.e. the percentage of energy demand change due to a one percent change of energy prices) is relative low, the companies can hardly react with a decrease of energy demand if energy prices grow.

Compared internationally, the electricity prices in Germany are relatively high. In 2012, the average industrial electricity tariff was 14.0 Euro Cent per kWh being 25% higher than the EU27 average. Compared overseas, the respective tariff in the US was 5.2 Cent, in China 9.1 Cent and in India 7.2 Cent (Middelbeck and Bosse, 2013). The private household tariff in Germany was 25.2 kWh, 37% higher than the EU27 average. In the US, the respective tariff was 8.9 Cent, in China and India 5.9 Cent (Middelbeck and Bosse, 2013). As the electricity demand is relative inelastic, increases in electricity prices hardly have any impact on electricity demand and thus directly increase operational energy costs. This induces danger of competitive disadvantages for the German industry.

The addition of renewable energies in Germany (mainly wind and solar PV) change the electricity market, both technically and economically. Technical problems are coming up as the supplies of wind and sun are weather-/day time dependent and thus fluctuating. Hence, the remaining power system (fossil power plants, electricity demand, power storage) must become very flexible in order to adapt to these fluctuations. Additionally, fossil "base load power plants" are no longer "existing", their power generation is replaced by renewable energies. Their capacity, however, is still needed as a safety reserve (Agora Energiewende, 2012). Economically, there is another cost structure of renewable energies (Figure 12): high capital expenditure (fixed costs), but hardly any variable costs (especially no fuel- and CO_2-costs. This leads to the so-called Merit-Order-Effect 1.

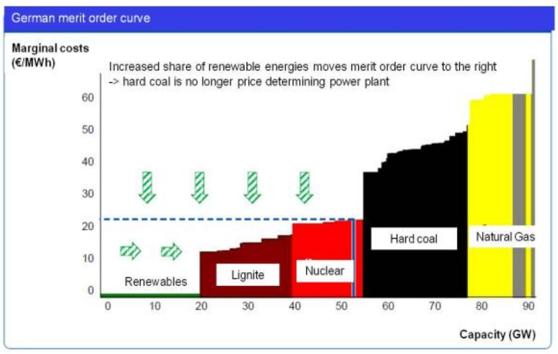
Figure 12:
Comparison of power generation full costs between fossil and renewable power generation (€/MWh)



Source: Weale (2013).

This effect stands for the fact that the low prices of CO_2-certificates lead to a closing down of natural gas power plants because of comparatively cheap power from lignite (Figure 13).

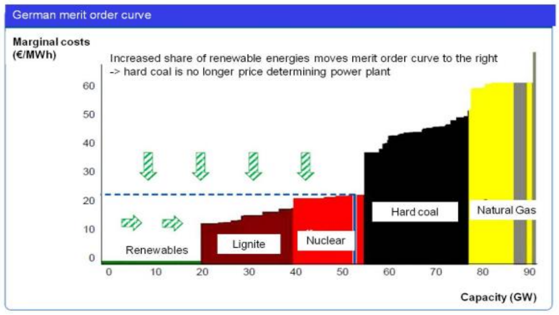
Figure 13:
Merit-Order Effect 1



Source: Weale (2013).

As there are almost no variable power generation cost for renewable energies, the marginal costs of one kWh_{EE} move towards zero (Figure 14). In addition, as for renewable energies, the Renewable Energy Law stipulates a mandatory connection and purchase by the network operators with fixed feed-in tariffs. Hence, increasing quantities of renewable energies replace hard coal and reduce the electricity price at the stock exchange (Merit-Order-Effect 2).

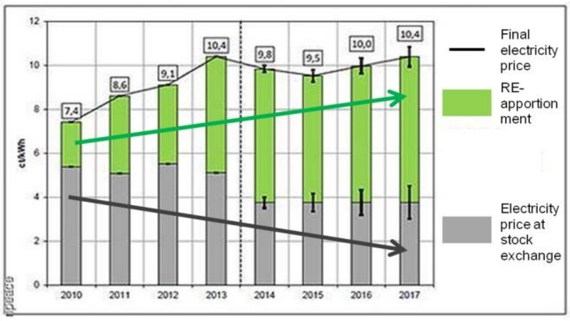
Figure 14:
Merit-Order Effect 2



Source: Weale (2013).

The renewable energy apportionment passes on difference between the revenues from renewable energy electricity sales at the stock exchange and fixed feed-in tariffs of the end customers. Exemptions exist for electricity-intensive companies with high international competition and the railway sector. As a result, the electricity price at the stock exchange decrease, but the RE-apportionment increases at the same time. Finally, the final customer electricity prices increase.

Figure 15:
Development of the RE-apportionment, electricity price at the stock exchange and final electricity price
(2010-2017, in Ct/kWh)

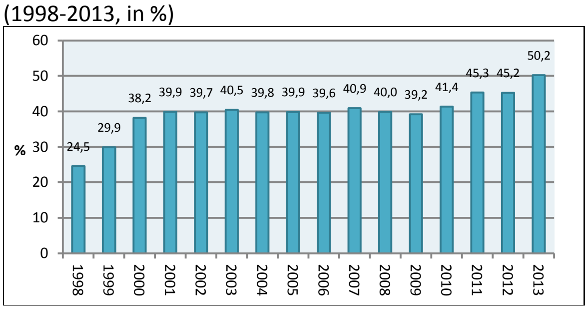


Source: Data from UNB, Öko-Institut, own depiction.

Result of this development is that the power generation costs gradually lose their importance for the final electricity price in Germany. The tax and levy share of the final electricity price in Germany increased from 24.5% in 1998 to 50.2% in 2013 (Figure 16). Hence, the leeway for the companies to react is getting narrower and narrower.

Mostly affected by the increase of the final electricity prices are private households and those companies not being able to be exempted from the RE-apportionment.

Figure 16:
Tax and levy share of the final electricity price in Germany
(1998-2013, in %)



Source: Bundesverband der Energie- und Wasserwirtschaft (2013).

According to an investigation of the IHK-NRW Chamber of Commerce and Industry – North-Rhine Westphalia (2013), especially for small companies (< 20 employees) the energy costs share of overall costs is particularly high. The sectors of traffic and storage, manufacturing industries, as well as hotels and gastronomy are particularly affected. If the RE-apportionment will be further increased, especially for companies with more than 200 employees the effects of the increase of the EEG-apportionment on the electricity costs are particularly high. Mostly affected sectors are trade, manufacturing industries as well as hotels and gastronomy.

4. Summary

Against the background of the development of the structure of energy carriers in Germany before and after the reunification, basis of German energy policy are the principles of efficiency, energy safety and environmental compatibility. Taking this into account, economic aspects include minimizing risks towards fluctuating energy prices and energy cost savings. Technical aspects and availability call for improved supply security and energetic independence, optimized procurement of energy and nuclear safety. Ecological aspects mainly include the reduction of greenhouse gases (esp. CO_2) as obliged towards the Kyoto Protocol and the decisions until 2050, e.g. in the EU context. For national environmental policy, reducing regional and local emissions (SO_2, NO_x etc.) are an important goal.

To provide a sustainable energy supply was an important challenge of the German government after the re-unification of East and West Germany in 1990 as the country's energy structure has changed significantly over the past decades. Since the 1950's, there was a turning away from black coal and lignite, until the 1970's, on both sides of the boarder, there was an increase of mineral oil for transport purposes. In West-Germany, nuclear energy capacities had been developed during the 1980's, whereas East Germany was still largely coal-driven. After the unification, renewable energies had been developed more and more, especially wind and solar energy.

The most import developments for organizing a national energy supply in Germany after the reunification were (a) liberalizing the markets for grid-bound energy carriers and (b) the "Energy Turnaround“.

Based on the first EU-Directives in 1996 and 1998, there was a liberalization of the German electricity and gas market transferring the EU-Directive into German law. Main pillars in the power sector are that every customer can chose from whom he purchases electricity and electricity suppliers can sell their electricity outside his region. Opportunities had been seen for lower energy prices due to competition. In the following, energy price reductions were only during the first years of liberalization. The subsequent concentration of suppliers lead to a re-increase of energy prices.

The nuclear disaster in Fukushima in 2011 lead to a massive change in German energy policy with closing down eight nuclear power stations and further development of renewable energies, closing down all nuclear power stations until 2022 (“Energy Turnaround“). Opportunities are existing in terms of developing regenerative electricity-generating capacities, increasing the energy efficiency in the secondary energy generation and -utilization, saving operational useful energy and expanding the network / -stability. Challenges are also obvious. The electricity prices are reduced at the stock exchange due to the “Merit-Order-Effect”, but electricity costs are increasing (EEG-apportionment etc.) for companies and households without any exemptions in the sense of the EEG. This implies the danger of competition disadvantages and cost increases, in particular for small and medium-sized enterprises (SMEs).

References

Agora Energiewende (2012): 12 Thesen zur Energiewende. Berlin.

Arbeitsgemeinschaft Energiebilanzen (diff. years): Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2012. Berlin, Münster.

Bundesverband der Energie- und Wasserwirtschaft (2013): Durchschnittliche Strompreisentwicklung für Abnehmer mit einem Jahresverbrauch von 3500 kWh.

BMWT(2013): Zahlen und Fakten Energiedaten. Nationale und internationale Entwicklung. Bundesministerium für Wirtschaft und Technologie, Referat III C 3 (Data: 20.8.2013).

IHK-NRW Chamber of Commerce and Industry – North-Rhine Westphalia (2013): Auswirkungen der Energiewende auf die Wirtschaft - Umfrage der IHK Nord Westfalen. Münster.

Middelbeck, S. and Bosse, M. (2013): Energiewende - Auswirkungen auf die betriebliche Praxis. Presentation at the 3. BDG-Environment Day, 16. May 2013. Mimeo.

Regierung der Bundesrepublik Deutschland (2011): Eckpunktepapier der Bundesregierung zur Energiewende-Der Weg zur Energie der Zukunft - sicher, bezahlbar und umweltfreundlich. Stand: 06.06.2011.

Sommer (2011): Energiewirtschaft - 3. Beschaffung leitungsgebundener Energie. Lecture at Power Engineering Saar.

Weale, G. (2013): Herausforderungen der deutschen Energiewende aus Sicht eines Energiekonzerns. Präsentation at Bochum University, 31.01.2013. Mimeo.