Report on the German power system

Version 1.2

COUNTRY PROFILE

Agora Energiewende

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IMPRINT

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Preface

Dear reader,

A glance at a map reveals a simple truth: Geographically speaking, Germany lies in the heart of Europe. Knowing that annual electricity demand in Germany is the highest in Europe, its generation fleet the largest, and its power system interconnected with ten countries with a total transfer capacity of more than 20 GW, one may wonder how anyone could claim that the Energiewende is purely a national endeavour. The opposite is true: German and European energy systems are heavily intertwined. Whatever happens in Germany has effects on its neighbours and vice versa. It is widely accepted that enhancing cooperation among European partners would create positive welfare effects for all. Sharing resources and developing joint regulatory frameworks could, for instance, help achieving system reliability at lower costs and balance variable power generation across Europe.

As cooperation starts with mutual understanding, Agora Energiewende asked the Regulatory Assistance Project (RAP) to develop a set of short and readable reports on the power sectors of Germany's neighbouring countries, focusing on key features, regulatory frameworks and important political developments. Originally, the country profiles were supposed to serve internal purposes only. But, as we believe this information could be valuable for others as well, we decided to publish it and make it accessible to everyone.

This country report on Germany is the third in our series. It reflects the status quo of summer 2015.

It is certainly not exhaustive. And we are well aware that things are changing very rapidly – especially in Germany in these days. Hence, we rather consider this report as work in progress that we will be reviewing on a regular basis. We would thus invite everyone to send us comments and corrections that could be incorporated into the next versions to countryprofile@agoraenergiewende.de.

May this country profile be helpful for your work!

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Acronyms — Table 1

ACER	Agency for the Cooperation of Energy Regulators
BKartA	Federal Cartel Office (Bundeskartellamt)
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit)
BMWi	Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
BNetzA	Federal Network Agency for Electricity, Gas, Telecommunications, Post, and Railway (Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen)
DSO	Distribution System Operator
EEG	Renewable Energy Act (Erneuerbare-Energien-Gesetz)
ENTSO-E	European Network of Transmission System Operators for Electricity
EnWG	Energy Industry Act (Energiewirtschaftsgesetz)
ESD	Effort Sharing Decision
ETS	Emissions Trading System
FiT	Feed-in Tariff
GW	Gigawatt
GWh	Gigawatt Hour
HHI	Herfindahl-Hirschman Index
ITO	Independent Transmission System Operator
kW	Kilowatt
kWh	Kilowatt Hour
PV	Solar Photovoltaics
RES	Renewable Energy Sources
Stadtwerke	Municipal Utilities
TSO	Transmission System Operator
TW	Terawatt
TWh	Terawatt Hour

1 Overview

This report explores the structure of the German power sector. It looks at the fuel mix, production and consumption, ownership and market structure, cross-border trade, and energy policy.

The German power system is the largest in Europe. Germany also has the highest share of renewable power in Europe in terms of installed capacity, and in fact is the country with the third largest amount of installed renewables capacity (excluding hydro) in the world.[1] In 2014, renewable energy accounted for more than one quarter of all electricity produced in the country. At the same time, hard coal and lignite contributed 44 percent of electricity production in 2014, while nuclear energy accounted for about 16 percent of production.

Four large power companies continue to dominate the German power market: E.ON, RWE, EnBW, and Vattenfall. These four companies are responsible for the bulk of electricity distribution, generation, and retail supply in the country. While competition has been slow to evolve, it has been increasing over the past few years. In 2012, more than 20 percent of all end-user customers had a contract with a competitive retail supplier. Moreover, as more renewables have come on the system, the ownership profile of generation has been shifting. While the big four power companies own most conventional generation (hard coal, lignite, nuclear, and natural gas), they own only about 5 percent of renewable resources. Private citizens, including farmers own 46 percent of renewable generation in Germany, followed by project developers, industry, and banks.

Germany has introduced a transformative energy transition called the *Energiewende*, to decarbonise the economy while phasing out nuclear energy by 2022. The *Energiewende* has been under development for over two decades, and many of its pillars were developed by the coalition government in 2000, e.g. the Renewable Energy Act and the first nuclear phase out. After the nuclear disaster in Fukushima in 2011, for the second time, Germany took the decision to phase out nuclear – after the first phase out was reversed in 2010.[2] The high-level national goals for the *Energiewende* have been integrated into Germany's *Energy Concept*, a national policy document which sets forth Germany's energy policy to 2050.[3]

The *Energiewende* has significant implications for the power sector, which is responsible for roughly 45 percent of greenhouse gas emissions from energy.[4] It calls for significantly improving energy efficiency, increasing the share of electricity generated by renewable resources, all while phasing out carbon-intensive and nuclear power plants. It also requires careful consideration of how to most effectively utilise cross-border interconnections with bordering EU member states to maximize economic effectiveness of the energy transition while maintaining grid stability in the region.

1 REN21, 2014, p. 16.

2 For a timeline of the *Energiewende*, see http://energytransition.de/2012/09/timeline-energiewende/.

3 BMUB, 2011.

4 In 2012, the power sector accounted for 46.4 percent of energy-related GHG emissions, followed by transport (19.78 percent), manufacturing and construction (14.65 percent), and other sectors. UNFCCC, n.d.

2 Industry Structure, Ownership, and Regulation

Germany at a glance Table 2

Main Indicators	
Total population	80.43 million (2011)
GDP	2.6 trillion EUR (2013)
Average household electricity consumption	3,369 kWh/year (2011)
Gross electricity consumption	589.8 TWh (2014)

2.1 Industry Structure

The German power system is dominated by four large companies, which continue to own significant generation, distribution, and retail assets: E.ON, RWE, EnBW, and Vattenfall. EnBW also owns part of the German transmission system, though as explained below, it has unbundled according to the independent transmission system operator (ITO) model under the Third Energy Package. Table 3 presents the ownership structure of transmission, distribution, generation, and retail service in the energy sector, and is followed by more detail on the structure of each branch of the power sector.

As mentioned earlier, there is a significant difference between the ownership profile of conventional generation and that of renewable resources.

Under the German *Energiewende*, the share of renewable resources in the electricity mix is planned to grow to 40-45 percent of gross electricity consumption in 2025, and 55-60 percent in 2035.[5] In 2014, renewables already accounted for more than a quarter of electricity produced in Germany, and 41 percent of installed capacity. As the share of renewable resources in the power generation mix increases, the ownership profile of generation assets in Germany is changing significantly, and is likely to continue to shift to a more distributed ownership model.

Ownership and operation of the German transmission system is divided between four transmission system operators (TSOs), as shown in Figure 2. As a result, there is not a single German grid for the highest voltage level, but four autonomous zones—and each operator is responsible for network functioning in its respective zone. The four system operators coordinate in order to maximize economic and operational efficiency among the four zones.[6]

Germany has unbundled most generation, transmission, distribution, and retail activities in the electricity sector. European law requires unbundling—or separation, to some degree—of generation, transmission, distribution, and supply activities of electricity companies. The European Electricity Market Directive permits several approaches to unbundling, from complete ownership separation, to legal separation of a company or functional separation of management functions.[7] According to the Energy Industry Act of 2005 (Energiewirtschaftsgesetz, or EnWG)[8], transmission and supply were required to be unbundled starting in 2005, and distribution system operators had until 2007 to complete legal unbundling. About 800 distribution companies with less than 100,000 customers were exempt from the legal unbundling requirement. Rather, they face a more

5 Targets are fixed in the Renewable Energy Act that has been adjusted in 2014 the last time.

6 Übertragungsnetzbetreiber, n.d.

7 Directive 2009/72/EC.

8 Gesetz über die Elektrizitäts- und Gasversorgung (Energiewirtschaftsgesetz), 2005.

Market Share of German Electricity Companies — Table 3

Sector	Leading Companies	Market Share	Total Number of Providers
Transmission	Amprion Transnet BW (ENBW) TenneT 50Hertz Transmission	**100%** Combined	4
Distribution	EnBW E.ON RWE Vattenfall	The big 4 distribution companies own and operate a significant portion of the distribu-tion system, though the exact level is not clear.	approximately 890* DSOs, about 700 of which are municipally owned *Stadtwerke*
Total Generation	EnBW E.ON RWE Vattenfall	**56%** installed capacity** (June 2014) **~59 %** of electricity generated (2012).***	over 1000 producers (not including indivi-duals)
Retail Suppliers	EnBW E.ON RWE Vattenfall	**45.5%** of total electricity offtake (TWh).****	over 900 suppliers

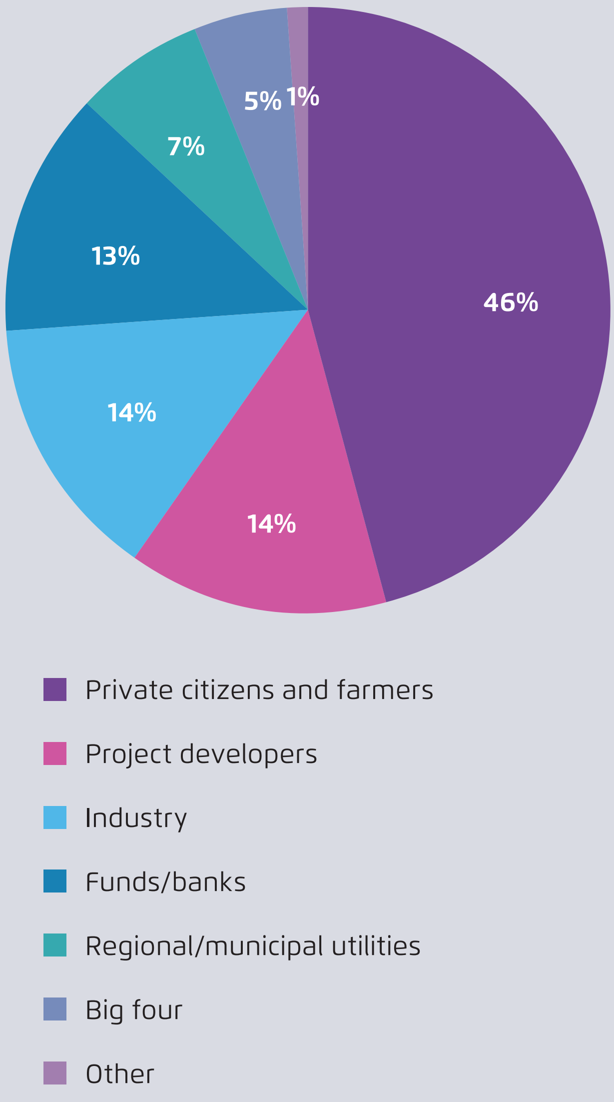
*Of this total number, 806 participated in the BNetzA survey; therefore, data regarding DSO activities is drawn from this smaller pool. See BNetza, 2013, p. 25., **BNetzA, 2014., ***Volume of electricity produced by the big four energy companies in 2012 taken from EnBW, 2013, p. 32. This is compared with data on total electricity produced in 2013, based on BMWi 2014b. As there are likely differences in the methods applied in each report, this number is an approximation., ****BNetzA, 2013, p. 27.

lenient requirement to unbundle operations (staff) or information.

Germany's four transmission system operators (TSOs) have unbundled according to different models. Two of the TSOs, TenneT and 50Hertz, are ownership-unbundled. That is, ownership and control of the transmission system is separated from that of distribution, production and supply. The two remaining TSOs, Amprion and Transnet BW, have unbundled pursuant to the ITO model, under which the TSO remains within the integrated company and the transmission assets remain on its balance sheet. Additional regulatory conditions are imposed to guarantee the independence of the ITO from the vertically integrated undertaking.

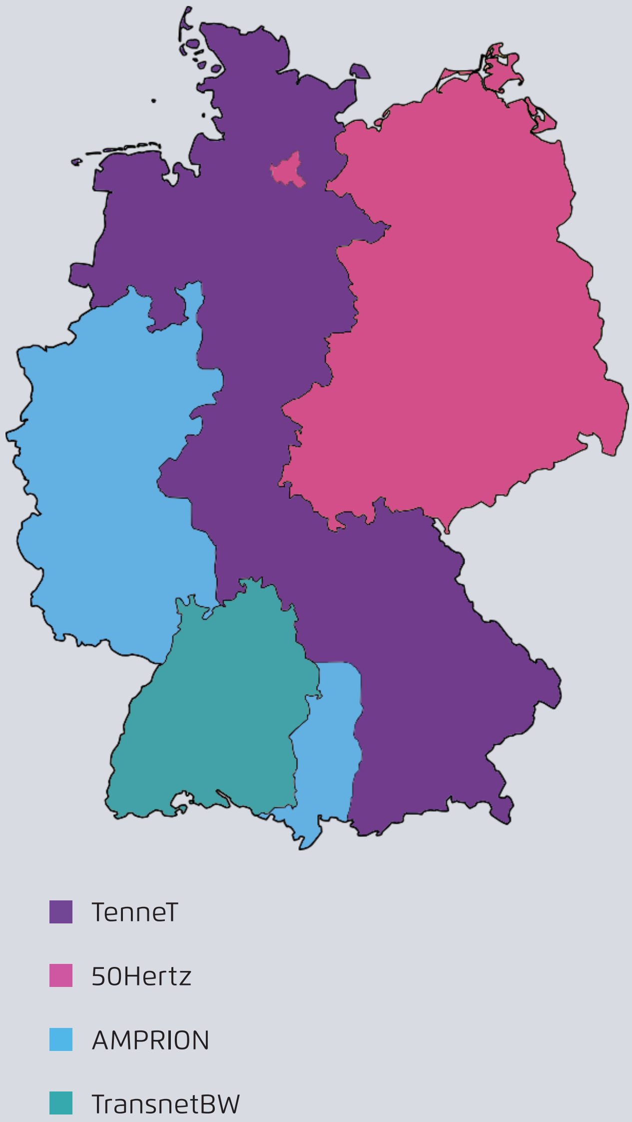
The distribution system in Germany is the most complex in Europe, with around 900 distribution system operators serving 20,000 municipalities. This includes the four large companies as well as about 700 *Stadtwerke* (municipally owned utilities) and a number of regional companies. The four large DSOs—RWE, EnBW, E.ON, and Vattenfall—operate a significant portion of the distribution grid through concession contracts with municipalities. Under these contracts, municipalities rent out their distribution franchise for up to 20 years. Under the Energy Industry Act, these concession agreements have to be renegotiated under non-discriminatory rules and can be cancelled. It is worth noting that there is a movement today for *Stadtwerke* to take over their own grid operations as many concession contracts come up for review.

Ownership share of renewable generation in Germany, 2012 Figure 1



Statistica, 2014

TSO geographic coverage in Germany Figure 2



Ene't, 2014; http://www.enet.eu/kartestromnetzbetreiber.html

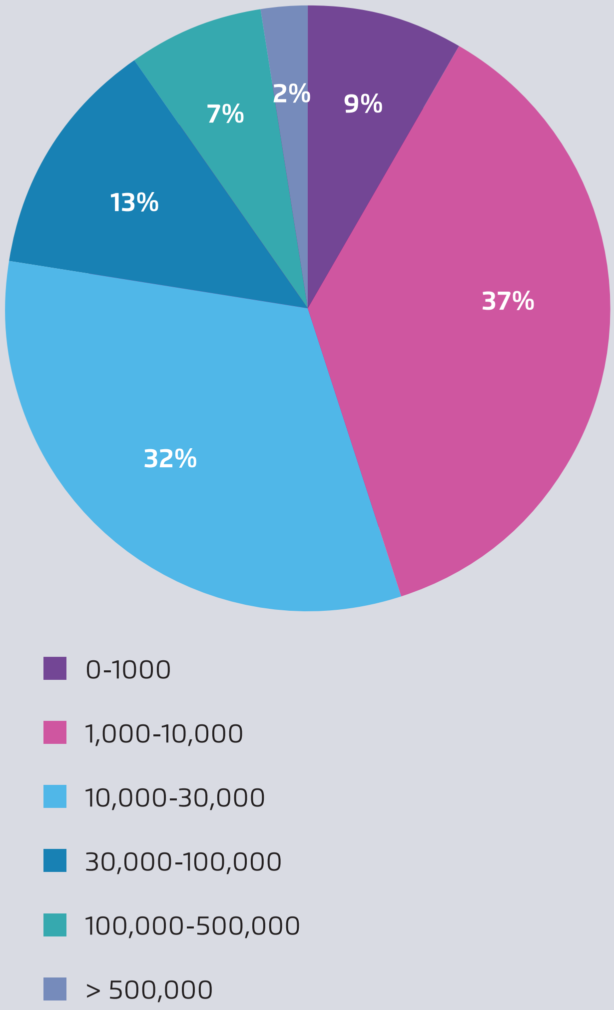
Many of Germany's DSOs are quite small; more than three-quarters of them supply under 30,000 metering points. Figure 3 illustrates the preponderance of distribution companies serving a small pool of customers.

In 2013, four companies owned about 56 percent of installed generation capacity in Germany: E.ON, RWE, EnBW, and Vattenfall.[9] Most of the capacity owned by these companies is coal, nuclear, and gas capacity.

The four biggest electricity generators are also the biggest retail suppliers, and in total they supplied 45.5 percent of the total delivered volume of energy (in TWh) to end-use

9 BNetzA, 2014.

Breakdown of distribution companies by size of customer base — Figure 3



BNetzA

customers in 2012.[10] The remaining energy is supplied by *Stadtwerke* and independent suppliers.

The retail market in Germany has grown increasingly competitive since retail competition was introduced in 1998. However, the percentage of switching from traditional suppliers for non-industrial customers (especially from traditional *Stadtwerke*) was relatively low in the beginning. More recently, retail competition has been increasing, and in 2012 about 20 percent of household customers had a contract with a competitive (i.e., not default) supplier. The retail market is discussed in more detail in Section 5.2.

2.2 Regulation

Energy policy in Germany is developed and implemented at the federal and regional levels. Within the government, the responsibility for energy policy is divided between the Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, or BMWi) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, or BMUB). Since 2014, responsibility for the power sector is mainly concentrated in the BMWi – with the exception of nuclear safety and climate protection.

On the federal level, the German power sector is chiefly regulated by the Bundesnetzagentur (BNetzA), the federal network agency, and by the Bundeskartellamt (BKartA), the federal cartel office. Both offices fall under the authority of BMWi. The power to regulate the power sector arises from the federal Energy Industry Act.

Federal Network Agency (BNetzA): This agency oversees development of the electricity, gas, telecommunications, postal, and railway markets. This includes regulation of competition and unbundling of the power and gas supply networks. BNetzA's responsibilities include ensuring non-discriminatory network access and the control of the network usage rates levied by the transmission system operators and distributers. The Federal Network Agency also supervises anti-competitive practices.

The German states[11] play an important role in regulation of the power sector as well. In particular, regulation of revenues is divided between federal (BNetzA) and state regulatory authorities. General rules are set on the federal level, while the legal execution and legal process are shared be-

10 BNetzA, 2013, p. 27.

11 There are 16 „Länder" (states) in total.

Ownership Structure of German Energy Companies

Table 4

Companies	Ownership
Amprion	RWE 25.1%, Commerz Real AG 74.9%*
TransnetBW	100% owned by EnBW
TenneT	100% owned by the state of The Netherland
50Hertz Transmission	60% Elia and Elia Asset; 40% IFM**
E.ON	100% privately owned, 75% institutional; 25% retail investors.
RWE	66% institutional, 13% private shareholders, 15% RWEB.***
EnBW	93.5% owned directly & indirectly by the state of Baden-Württemberg
Vattenfall	100% owned by the Swedish government

*Amprion. 2011. Retrieved from http://www.amprion.net/pressemitteilung-54., ** 50hertz, 2014., *** RWE, 2013.

tween federal and state regulatory authorities. Today, Germany has one federal and 11 state regulatory authorities in place (five states have decided to shift all of their regulatory responsibility for the power sector to BNetzA). Grids covering more than one state, and networks with more than 100,000 customers, are regulated by BNetzA as well.

Federal Cartel Office (BKartA): This office is charged with ensuring market competition in Germany, primarily through the control of abusive practices by dominant companies. It is responsible for verification regarding energy prices levied by suppliers that operate on a national basis. The Bundesländer (state) cartel authorities or the civil courts address allegations of excessive rates for end customers in their states.

The federal and state cartel offices and regulatory authorities share responsibility for liberalisation and deregulation of the energy markets. Collectively, they focus on promoting a competitive market structure, consistent with the Energy Industry Act and market liberalisation.

2.3 Transposition of European Energy Policy

Germany has transposed the European directives on the internal markets in electricity and natural gas into national legislation. Implementation of electricity market liberalisation, however, continues, with competition limited, but increasing gradually.

Germany has transposed European climate and renewables directives into national law; however, it is delayed in implementing the European Energy Efficiency Directive.[12]

12 Directive 2012/27/EU.

3 Energy Production and Consumption

3.1 Installed Capacity

As of July, 2014, Germany had an installed capacity of 192 GW. Renewables account for 83 GW, or about 44 percent of total installed capacity. This is the result of Germany's aggressive policies supporting renewable energy, particularly through the feed-in tariff (FiT), described in more detail in Section 8. Natural gas, hard coal, brown coal (lignite), and nuclear also account for a significant share of installed capacity.

Main Indicators — Table 5

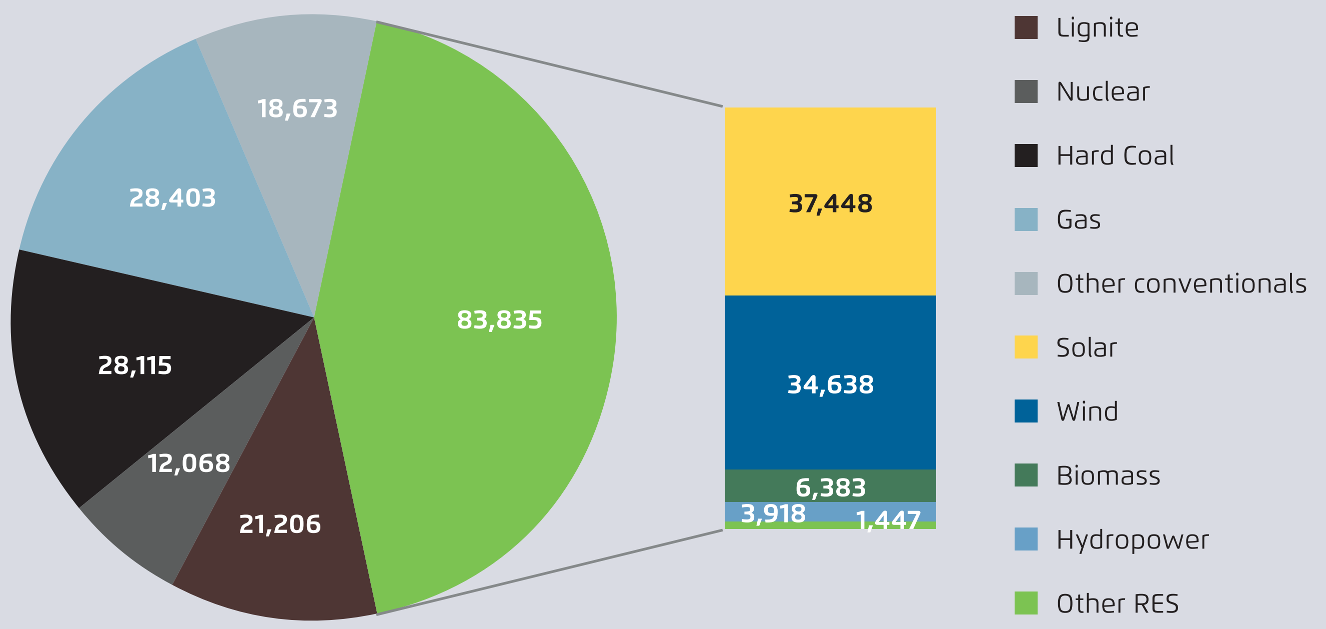
Installed capacity	192 GW (7/2014)
Peak demand	82.7 GW (2013)
Gross electricity consumption	589.8 TWh (2014)

The renewable energy mix, in terms of installed capacity, is led by solar photovoltaics (PV) and onshore wind. Biomass, hydro, and other renewables (such as geothermal) taken together account for less than a quarter of all installed renewables capacity.

3.2 Production

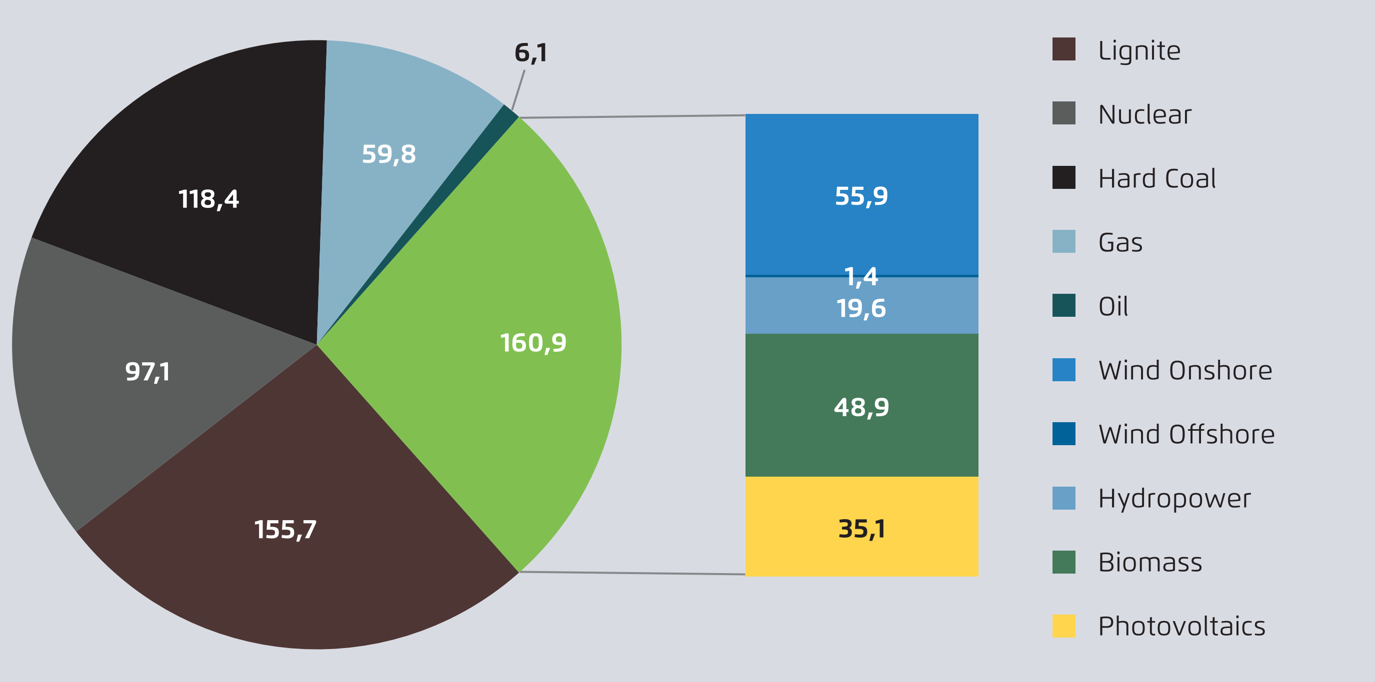
Lignite and hard coal accounted for about 44 percent of all electricity produced in Germany in 2014. Renewables accounted for just over a quarter of all electricity production. Nuclear power, which is to be phased out by 2022, accounted for 16 percent of power production in 2014.

Installed capacity 7/2014 in MW (Total: 192 GW) — Figure 4



BNetzA, 2015, p.29.

Electricity Production 1990-2014 (in TWh) Figure 5



AG Energiebilanzen 2015

In 2014, German electricity production from renewable sources reached 161.1 TWh, or 25.7 percent of all electricity produced that year[13]. It is important to note, however, that, the share of renewable energy in total electricity production has been much higher (and lower) at certain times of the year. In 2014 the maximum share of renewable energy in electricity consumption in Germany in one specific moment was on 11 May 2014 (noon) with roughly 80 percent of total consumption. Data for the year 2014 indicate a share of 27.3% of total consumption.[14] As the share of installed renewables capacity increases, so will the average contribution of renewables to electricity production, as well as the maximum share of production at times with generous wind and sun.

13 preliminary data, AG Energiebilanzen, 2014a; data for 2014 in this chapter are preliminary according to AG Energiebilanzen 2014a. More information in detail for 2014 can be found in Agora Energiewende 2015.

14 AG Energiebilanzen, 2014.

3.3 Consumption

In 2014, gross electricity consumption was 589.8 TWh, which was 2.5 percent less than in 2013.[15] This represents a roughly 4.6 percent decrease in gross electricity consumption since 2008. Under the goals established pursuant to the *Energiewende* (see Section 7), by 2020 Germany aims to reduce gross electricity consumption by 10 percent compared with 2008.

It is worth noting that trends in Germany's energy productivity reflect a significant decoupling of energy growth from energy consumption (see Figure 15 in chapter 9). Further improvements in energy productivity can be expected if Germany is to meet its energy saving goals under the *Energy Concept*.[16]

15 AG Energiebilanzen 2014a.

16 BMWi, 2014a, p. 8. According to the most recent evaluation of progress on the *Energiewende*, Germany is falling short of meeting its energy efficiency targets for 2020.

3.4 Peak Demand

Germany continues to be a winter peaking country primarily due to the demands of lighting and water and space heating; 6.1 percent of space heating is fueled electrically, including night storage systems and heat pumps.[17]

The annual load profile for Germany shows, that the annual peak of 82.7 GW was reached on 12 November 2014 at 5:00 pm.

Similarly, in 2013, peak demand was reached on December 5 at 6 pm, totaling 83.1 GW. The lowest demand in 2013 occurred on June 2 at 7 am, totaling 32.47 GW.[18]

3.5 Planned Conventional Power Plants

As of July 2014, 6,558 MW of thermal generation was under construction, with completion scheduled by 2016, while 11,251 MW of capacity are planned to leave the system by 2018. Against the background of bottlenecks in the transmission grid between North and South, Southern Germany is experiencing some challenges regarding resource adequacy – in part due to the decommissioning of 5 GW of nuclear capacity in 2011, partly due to planned closures of additional 3.869 MW. According to BNetzA, Southern Germany can expect a potential negative balance of up to 5,717 MW by 2018.[19] It should be mentioned that the government can reject applications for closure of plants for system stability reasons (*Systemrelevanz*).

17 BDEW, 2014, p. 19.

18 ENTSO-E, 2014a.

19 All these figures are changing frequently; hence, please, refer to BNetzA for the latest updates, especially the Kraftwerksliste and the Kraftwerksstilllegungsanzeigenliste; www.bundesnetzagentur.de.

4 Imports and Exports

Germany has significant interconnection capacity with neighboring EU member states. It is interconnected with Austria, Switzerland, the Czech Republic, Denmark, France, Luxembourg, the Netherlands, Poland, and Sweden.[20]

In 2012, Germany had 21.3 GW of available interconnection capacity—a high level compared with an annual peak demand of 83.1 GW.[21] Still, only about half of this export capacity is utilized at any given time. Export capacity has, on average, been growing over the past few years, and is expected to continue to grow as planned interconnections expand cross-border transmission capacity with several neighbouring countries.[22]

Germany is a net energy exporter. The biggest export markets are The Netherlands and Austria, while it draws net energy imports mainly from the Czech Republic. Trade between Germany and France requires a closer view: While Germany exports electricity according to financial transactions, physical flows are to a certain extent transit flows from France via Germany to Switzerland. There is a significant volume of unplanned physical flows (loop flows) occurring between Germany and its neighbours. Due to constraints on the German transmission system, the excess power from the north travels through the transmission systems of neighbouring countries, and particularly through Poland, the Czech Republic, or via the Netherlands, Belgium, and France.[23]

In response to these unplanned flows, German TSOs have taken several steps with neighbouring countries. Phase-shifting transformers, which limit the flow of electrons cross-border, have been deployed to limit transit flows through The Netherlands to Belgium and France already 15 years ago. More recently, 50Hertz signed a virtual phase shifter agreement with PSE Operator, the Polish TSO. A virtual phase shifter agreement is a contractual agreement defining a maximum limit for cross-border electricity flows, with flows limited where necessary via re-dispatching. Physical phase shifting transformers are expected to be installed around 2016 to limit flows through the Czech Republic and Poland.[24]

Another solution to the problem of unplanned flows has been set forth in an analysis commissioned by the regulators from Poland, the Czech Republic, Slovakia and Hungary. The study identified significant unplanned flows in the CEE region, with Poland and the Czech Republic most strongly affected. It recommended coordination of all cross-border transactions via the introduction of market coupling and flow-based capacity allocation methodology,

Import/Export balance 2003-2014 (in GWh, physical flows) Figure 6

AG Energiebilanzen 2015

20 Amcharts, n.d.

21 BNetzA, 2013, p. 13.

22 ENTSO-E, 2012a.

23 ACER 2014, p 149ff, BNetzA, 2013, p. 90.

24 BNetzA, 2013, p. 90.

Import/Export balance (exports – imports) (in GWh, physical flows) Table 6

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
AT	4,457	8,376	8,957	11,621	9,390	7,895	7,955	10,566	8,748	7,126	9,000
CH	9,044	16,501	10,777	11,921	11,149	10,506	11,972	11,238	9,591	7,968	6,900
CZ	-12,972	-12,617	-11,407	-8,535	-6,614	-7,722	-8,836	-7,522	-5,742	-6,956	-2,400
DK	3,338	583	3,972	1,472	1,364	3,615	3,769	-2,149	-6,738	2,539	-500
FR	-15,086	-15,739	-15,334	-15,705	-9,701	-9,171	-14,331	-20,176	-12,437	-10,574	-14,000
LU	4,177	4,248	4,330	4,413	4,467	4,387	4,798	4,655	4,592	4,586	4,600
NL	16,799	18,935	22,053	17,763	18,030	5,360	5,870	6,368	21,817	24,219	24,000
PL	2,708	1,220	1,826	4,843	5,482	5,483	5,167	4,705	5,877	4,909	9,200
SE	176	-2,663	453	-867	-1,964	221	1,348	-1,419	-2,612	-29	-1,000
Totals	**12,641**	**18,844**	**25,627**	**26,926**	**31,603**	**20,574**	**17,712**	**6,266**	**23,096**	**33,788**	**35,700**

ENTSO-E, n.d.; data for 2014: AG Energiebilanzen

stressing the need for all significant constraint boundaries to be included in the process.
Because of its central location in Europe and high level of interconnection with neighboring member states, Germany belongs to four of six Electricity Regional Initiatives.[25] Over the past few years, the German market has become more closely linked to neighboring markets through market coupling:

→ Nordic market and Germany (2009)
→ Central-West region (2010)
→ Central-West and Nordic region (2013)[26]

In fact, market coupling and flow-based capacity allocation methodology are to be implemented as part of the market integration process, and as defined by the Capacity Allocation and Congestion Management (CACM) Code.[27] The respective Guideline is currently progressing through the Comitology procedure, following a recommendation by ACER to adopt the Guidelines.[28] It recommends that bidding zones be defined so as to support congestion management and market efficiency, by defining bidding zones by congestion rather than national boundaries. However, the text is not explicit on this point and the question of what might constitute the most efficient means of managing congestion – market splitting, or coordinated redispatch – is left open.

25 ACER, 2012. For more on the Electricity Regional Initiatives, see BNetzA, 2009.

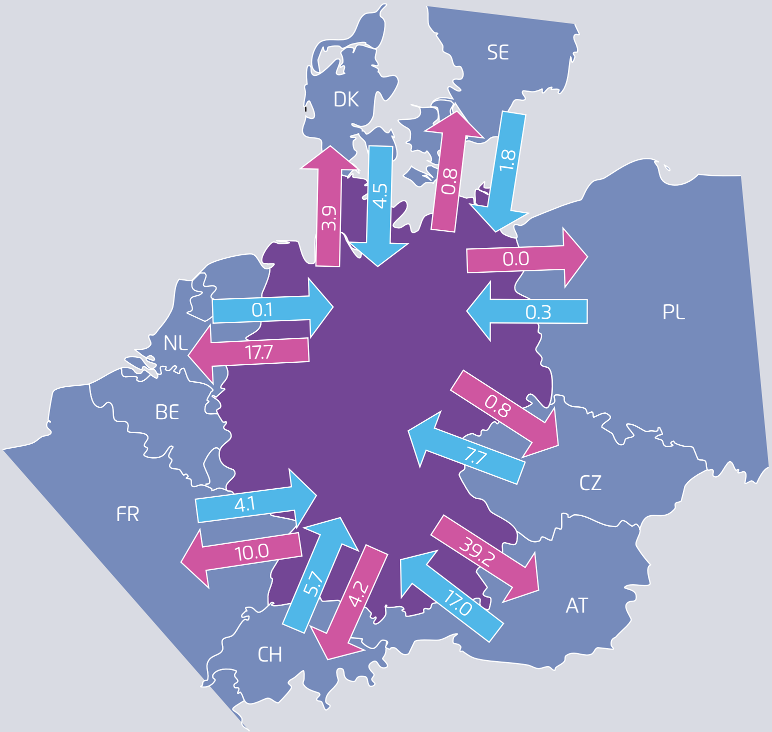
26 CAO, n.d., TenneT, n.d.

27 ENTSO-E, 2012b.

28 ENTSO-E, 2013.

Commercial electricity exchange between Germany and its neighbours, 2014

Figure 7



Exports: 76.5 TWh (2013: 77.3 TWh)
Imports: 41.1 TWh (2013: 43.0 TWh)
Commercial flows in TWh

ENTSO-E (2014)

5 Electricity Market

5.1 Wholesale Market, Prices and Liquidity

5.1.1 Electricity Market Design

The German wholesale electricity market is broadly made up of three elements: (1) a forward market; (2) a day-ahead market; and (3) an intra-day market. Electricity supply deliveries in the forward market can be negotiated up to seven years in advance, but for liquidity reasons typically only look out three years, and in fact most futures trading focuses one year ahead.[29]

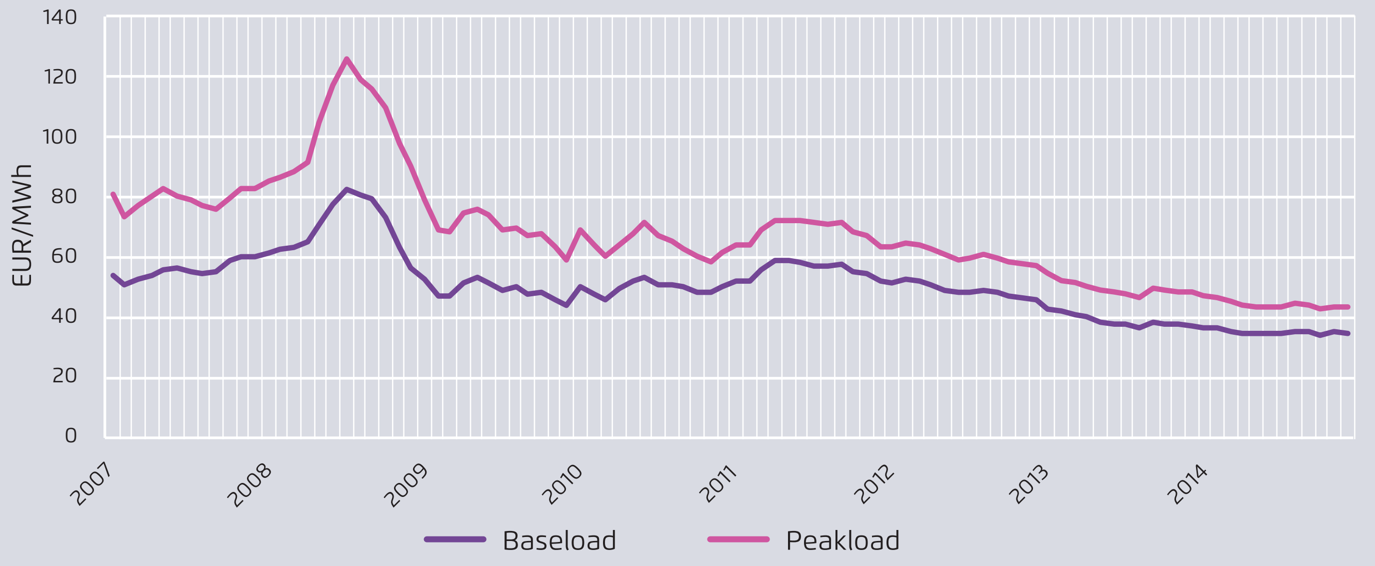
While the majority of wholesale transactions occur through bilateral "over the counter" contracts, an increasing proportion of transactions occur via power exchanges.[30] Most trading for Germany occurs on three exchanges: the European Energy Exchange (EEX) in Leipzig, the EPEX SPOT in Paris, and the Energy Exchange Austria (EXAA) in Vienna.[31]

5.1.2 Market Liquidity

As described earlier, the generation market is quite concentrated, with the four largest private supply companies owning about 56 percent of installed capacity and producing about 59 percent of the electricity generated in Germany. Total output of the largest four producers in 2012 was as follows:

→ RWE, 155.5 TWh
→ E.On, 93.1 TWh
→ EnBW, 59.05 TWh
→ Vattenfall, 68.8 TWh[32]

Wholesale electricity prices in Germany, forwards 2007 – 2014 Figure 8



EEX, 2014.

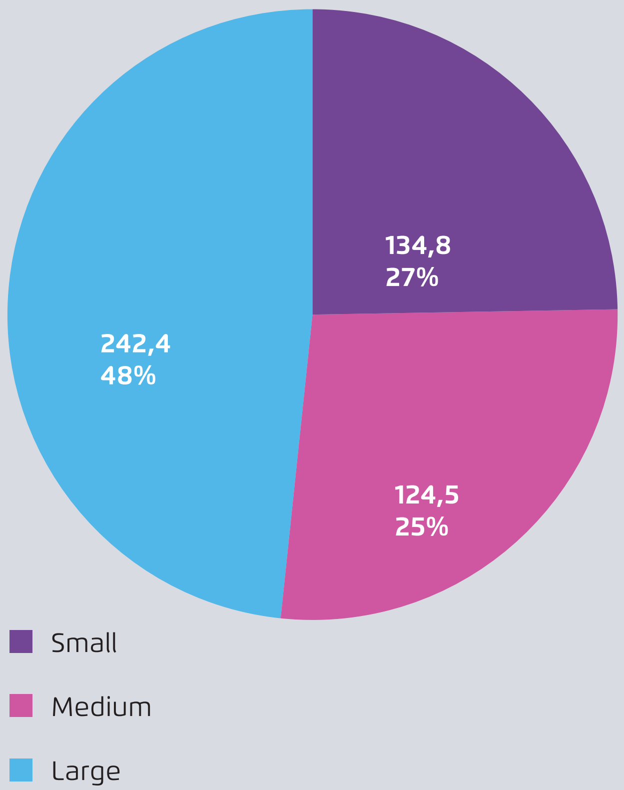
29 For more on the wholesale markets, see BNetzA, 2013, pp. 91-119.

30 BNetzA, 2013, p. 14.

31 BNetzA, 2013, pp. 93-94.

32 EnBW, 2013, p. 32.

Share of consumption by customer class, TWh (2012) Figure 9



BNetzA, 2013, p. 26. Note that these data are based on bottom-up analysis performed by BNetzA, and reflect responses from 806 out of 888 suppliers.

Wholesale market concentration in Germany remains relatively high. In 2011, the wholesale market Herfindahl-Hirschman Index (HHI)[33] was measured at 2,012, which is considered a highly concentrated market.[34] However, it is important to note that market concentration is lower in combined bidding zones, such as the Central-West and Nordic regions. Moreover, market liquidity has been increasing over the past few years, in part due to the obligation that TSOs sell renewable energy on the spot market.

Over the past several years, wholesale market prices have been declining steadily in Germany, as illustrated in Figure 8. This is due to a combination of an oversupply of low-marginal cost generation, as well as flat demand due to the recession and increased energy efficiency. The very low marginal production cost of renewables, often cited as a cause of low wholesale prices, rarely if ever sets market clearing prices and is therefore not directly implicated, anymore than is the very low marginal cost of nuclear or lignite. These resources are early in the merit order, have limited dispatchability, and therefore push other resources to the margin when they are available. It is the mix of those other resources – both their marginal costs and their flexibility to respond to the availability of lower-cost energy from nuclear and renewables – that is driving and will drive the trend in wholesale prices for the foreseeable future.

5.2 Retail Market

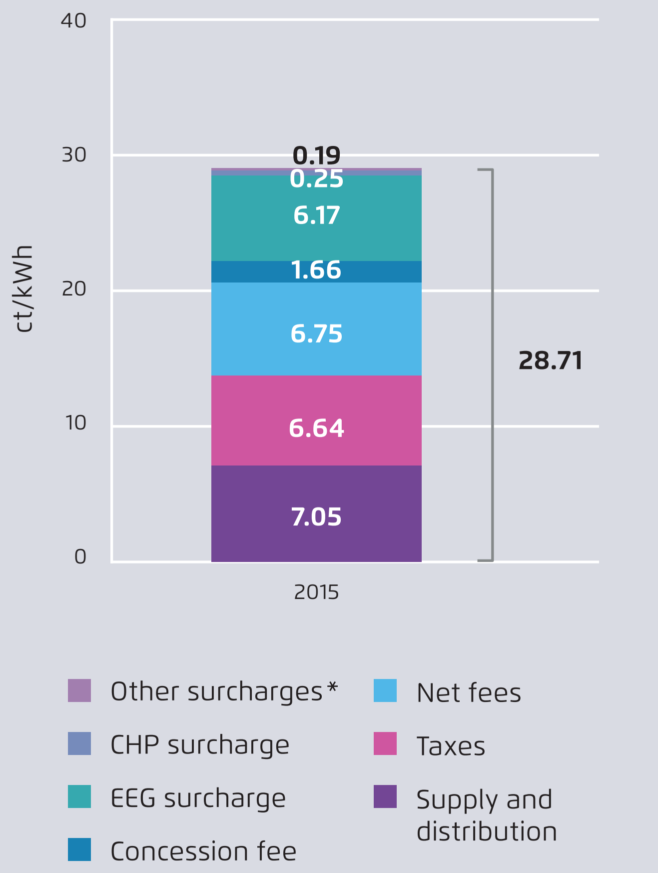
Germany's economy is highly industrialized, and as illustrated in Figure 9, large industrial customers accounted for nearly half of German consumption in 2012. Residential customers, which are the largest customer class by number, accounted for about a quarter of total consumption, and smaller industrial and business customers accounted for the just over a quarter.

Since 1998 all customers have been able to choose their electricity supplier. However, in practice the percentage of switching from traditional suppliers for non-industrial customers (especially from traditional *Stadtwerke*) has been a relatively slow process. When retail competition was first introduced, there were no standards for contracts, times and switching costs, which caused a great deal of uncertainty. As regulation has been introduced to control these factors, customer switching has increased. In 2012, 20 percent of customers had contracts with a competitive supplier (i.e., not their default supplier), and more

33 The HHI is defined as the sum of the squares of the percentage market share of each market participant. The Index can range in value from 0 to 10,000. The higher the index, the more concentrated the market. A market with an HHI of less than 1,000 is generally considered competitive, a market with an HHI in the range of 1,000 to 1,800 would be considered as moderately concentrated, while a market with an index above 1,800 would be considered highly concentrated.

34 European Commission, 2011.

Average volume-weighted retail price for household customers (ct/kWh) in 2014* Figure 10



BDEW 2015; *Other charges are the sum of: billing, 19 Strom-NEV surcharge, metering operations, offshore liability surcharge, KWKG surcharge, and metering.

than 43 percent of customers remained with their default supplier, but under a competitive contract. The remainder remained on a default contract with their default supplier.[35]

For 2013, Germany's retail electricity sector was identified as having a low level of market concentration, falling well below a HHI of 1,000.[36] As mentioned earlier, in 2012 the four biggest retailers supplied 45.5 percent of the total delivered volume of energy (in TWh) to end-use customers.[37]

35 BNetzA, 2013, p. 128.

36 ACER, 2014, p. 49.

37 BNetzA, 2013, p. 27.

The remaining energy is supplied by publicly owned *Stadtwerke* (most or fully owned by the local authority) and independent suppliers.

Electricity prices (in ct/kWh) have risen for both household and industrial customers over the past years. Household electricity prices have increased for default customer contracts with default suppliers as well as for those with non-standard contracts with a default or other supplier.[38] The main reasons for the steep increase in prices are:

→ Increases in fees (in particular the EEG surcharge)
→ Increases in taxes
→ Increases in cost of energy procurement[39]

The EEG surcharge (arising from the German Renewable Energy Act – Erneuerbare-Energien-Gesetz) alone increased from 8.8 percent of the average household customer bill in 2010 to 17 percent in 2013. This increase is the result of a combination of factors, including the growing share of renewable generation supported by the FiT, decreasing wholesale energy prices (which have the effect of increasing the level of FiT which must be paid), and exemptions for many large industrial customers which has transferred these costs on to other customers. In 2016, the EEG surcharge will increase from 6.17 ct/kWh in 2015 to 6.354 ct/kWh.

As a caveat it shall be noted that electricity prices for industrial consumers vary significantly in Germany. Especially many large energy-intensive companies are exempted almost entirely from levies and taxes. The following section discusses this problem in slightly more detail.

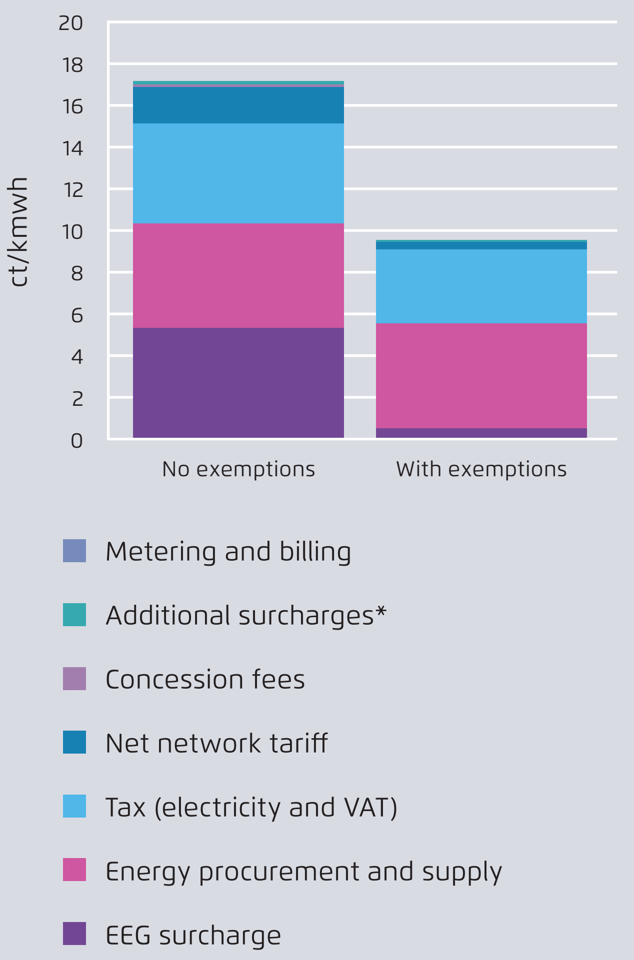
5.2.1 Breakdown of Electricity Bill

In order to understand electricity prices in Germany, it is important to understand the significant portion of the bill covering taxes and levies. For residential customers, taxes and levies account for roughly half of their electricity bill, while for industrial customers the share rises to almost 60 percent.

38 BNetzA, 2013, p. 141.

39 BNetzA, 2013, p. 152.

Components of industrial electricity (SMEs) bill in Germany (ct/kWh) Figure 11



BNetzA, 2013, pp. 15-16., *KWKG, 19 StromNEV, and offshore liability surcharges.

Figure 10 illustrates the charges on an average household customer's bill. The energy and network tariffs account for about half the bill, while taxes and surcharges account for the rest. The EEG surcharge accounts for 17 percent of the overall bill, followed by VAT at 15 percent.

Compared to other Member States, German household electricity prices in 2014 were the second highest in the EU, at 29 ct/kWh.

Figure 11 demonstrates the components of a medium-sized industrial customer's electricity bill.[40] On the left is the bill with all taxes and levies, which account for about 60 percent of the bill. On the right is the reduced bill, re-calculated based on the assumption that the customer qualifies for all available exemptions.

As Figure 11 demonstrates, the difference can be significant. Without exemptions, the small or medium sized industrial customer in this example will pay just over 17 ct/kWh, while when the maximum exemptions apply, they pay just over 9.5 ct/kWh – a 44 percent reduction. The largest cuts are found on the EEG surcharge, which pays for support of renewable energy in Germany, and was reduced by more than 90 percent from 6.24 ct/kWh to 0.45 ct/kWh in 2014.[41] Taxes drop by nearly a quarter, and the network tariff drops by nearly 80 percent. Concession fees are completely eliminated.[42]

The availability of exemptions for many industrial customers makes it difficult to compare industrial electricity prices in Germany with those in other countries. However, one can state that electricity prices for large industrial consumers in Germany are at a similar level or lower than in most other European countries (Figure 12).

The difference between industrial prices in Germany with and without available exemptions can be significant. Without exemptions, industrial customers in Germany pay one of the highest retail rates in Europe. With exemptions, they pay one of the lowest.[43]

Furthermore, some large energy-intensive companies pay even less for electricity, because they are exempted from

40 In this case, the customer is assumed to have 24 GWh/year annual consumption; 4,000 kW annual peak load and 6,000 hours annual usage time, and be connected to the medium-voltage grid (10 or 20 kV). BNetzA 2013, p. 15.

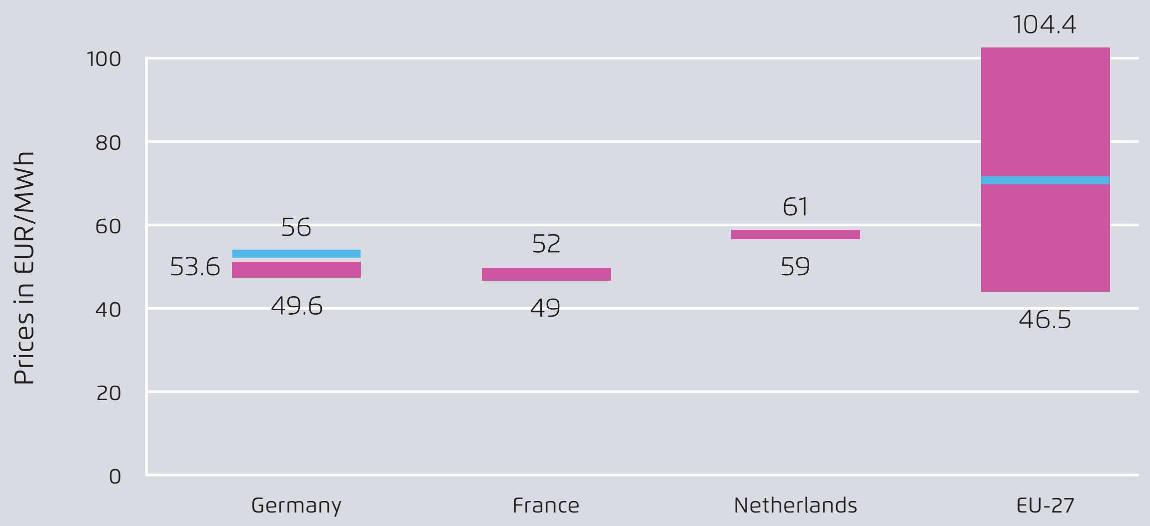
41 EEG surcharge was 5.28 c/kWh in 2013, 6.24 c/kWh in 2014 and will be at 6.17 c/kWh in 2015.

42 BNetzA, 2013, pp. 15-17.

43 European Commission, 2013.

Comparison of end-use electricity prices in 2012 for energy intensive industries (150 GWh annual consumption)

Figure 12



Agora Energiewende 2014.b

basically all taxes and surcharges while purchasing their electricity at the wholesale market at record low prices.[44]

5.3 Grid Cost Allocation

In Germany, all grid costs are allocated to end-use customers. Supply only has to pay the one-time cost of grid connection; all other costs are borne by end users. Costs are allocated differently among large and small end-use customers. Charges for industrial customers are based primarily on the level of peak demand (kW) that is coincident with system peak. Grid tariffs for these customers are charged as a combination of per kW demand charges and per kWh energy-use charges, based on the demand and energy use characteristics of the customer class. The demand charge tends to be the higher charge, while energy-use charges are lower. For low-energy use customers (residential and small businesses), grid costs are charged primarily on an energy-use basis, plus a fixed customer charge.[45]

Grid tariffs are calculated based on direct grid costs and certain components of providing "system services," namely:

- → At the transmission level, system costs consist of the cost of managing grid bottlenecks (i.e., redispatch, renewables curtailment, and capacity payments for reserves, minus energy rates for called reserves).
- → At the distribution level, the balancing costs for deviations associated with standard load profiles.

An important feature of grid cost allocation in Germany is that costs are allocated exclusively within a distribution grid operator's territory. This has the practical effect that grid tariffs can vary substantially from one distribution territory to another. There is one exception to this: A nationwide system of cost equalization governs the costs of hooking up offshore wind parks.

44 http://www.agora-energiewende.de/fileadmin/downloads/publikationen/Analysen/Comparing_Electricity_prices_for_industry/Agora_Comparing_Electricity_Prices_for_Industry_web.pdf

45 For more on grid tariff design, see Jahn, 2014.

The 888 or so DSOs are heterogeneous and thus have very different network costs, as a result to the density of demand within a given distribution territory (number of customers and level of consumption), and investments for RES connections. The connection costs of wind parks, biomass power plants, and PV systems are exclusively borne by customers of the local distribution networks where the facilities are located. As a result, the network tariffs for customers can vary widely, from 4.2 to 8.88 ct/kWh for residential customers in 2014.

Germany faces a challenge with grid cost allocation within this framework as the share of distributed generation increases. When the tariff system was established, distributed generation was seen as a way to unburden the upstream power grid. This system benefit (avoided upstream voltage costs) was passed to distributed generators in the form of reduced grid tariffs. As more and more distributed generation has come on the system, however, the tariff exemptions have often come to exceed actual system benefit. Almost all of Germany's more than 1.5 million PV facilities are connected to the distribution networks. On the one hand, the high penetration of distributed generators is driving grid expansion, particularly in rural areas. On the other hand, these same generators benefit from reduced grid tariffs, significantly raising distribution costs for other customers. The cost reallocation required by these grid tariff exemptions represent (nationwide) on the order of 9 percent of total grid revenues.[46]

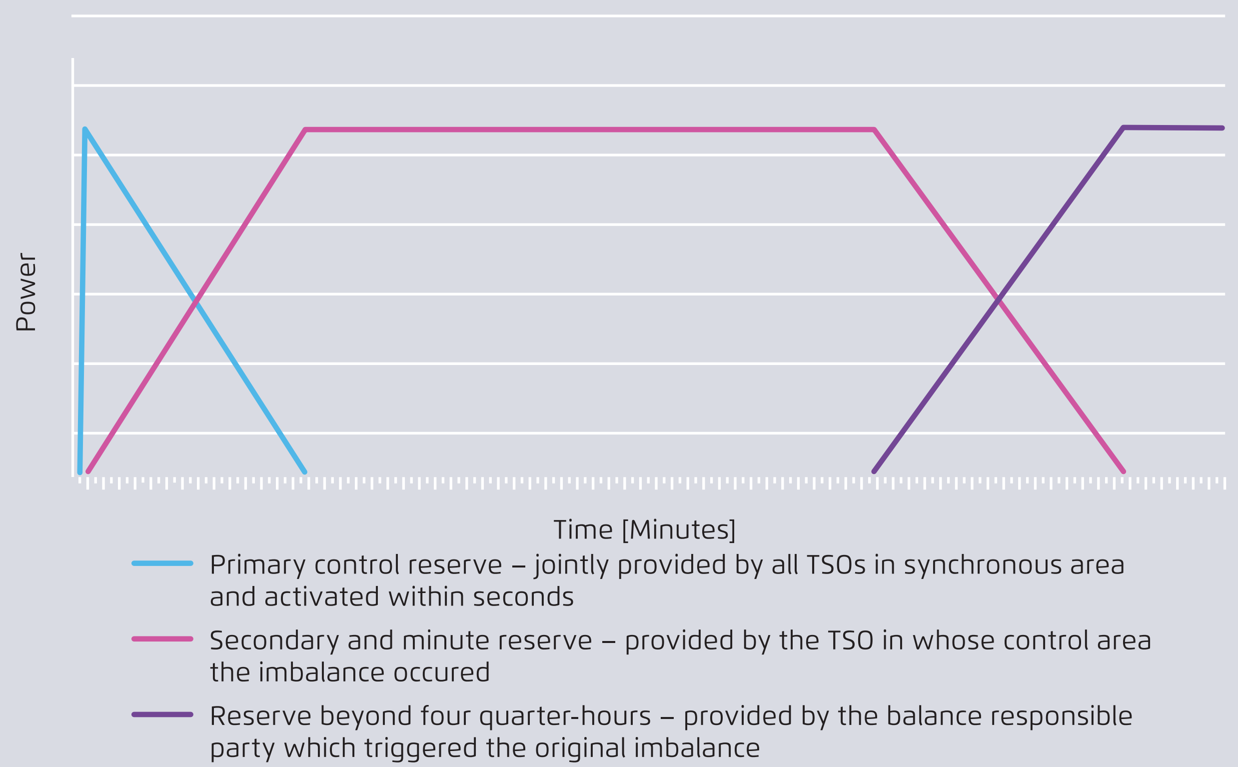
This problem is exacerbated by the fact that grid costs are paid almost entirely within each DSO's territory. This has led to very different costs associated with distributed generation from one distribution territory to the next. And as Germany continues to implement the *Energiewende*, the penetration of distributed renewables can be expected to increase. Small, rural territories are often impacted more significantly, as a small number of customers must pay for a relatively high level of distributed generation. This is in comparison with larger, more populated DSO territories, where reduced grid tariffs for distributed generation are shared across a broader customer base.

46 At the same time, self-generation, which also has the result of reduced payments for grid services, only contributes to reallocation of about 1 percent of grid revenues. See Jahn, 2014.

6 Electricity Balancing/Reserve Markets

The energy balancing market in Germany (also known as the system services market) consists of services structured into three main tiers: (1) the primary control reserve, activated within 30 seconds and available up to 15 minutes; (2) the secondary control reserve, activated within 5 minutes and available up to 15 minutes; and (3) tertiary control reserve, activated within 15 minutes and available for a minimum of 15 minutes up to 1 hour, or several hours in the case of several incidents. Primary and secondary reserves are procured on a weekly basis; tertiary reserves, on a daily basis.[47]

German energy balancing market | Figure 13



Regelleistung.net, n.d.

47 Übertragungsnetzbetreiber, n.d., a.

7 Decarbonisation Policies and the German *Energiewende*

The EU has set the goal of reducing GHG emissions 20 percent below 1990 levels by 2020. This target is divided between sectors covered under the EU Emissions Trading System (ETS), covering about 45 percent of total GHG emissions, and the Effort Sharing Decision (ESD), which sets targets for all remaining economic sectors. Under the ETS Directive there are no country-level targets; however, to implement the *Energiewende*, Germany has set a target of reducing GHG emissions by at least 40 percent compared to 1990 levels by 2020.[48] The ESD caps Germany's GHG emissions in non-ETS sectors at 14 percent below 2005 levels by 2020.[49]

The *Energiewende* aims to reduce greenhouse gas emissions economy-wide by 80–95 percent by 2050.
The high-level national goals for the *Energiewende* have been integrated into the *Energy Concept*, a national policy document which sets forth Germany's energy policy to 2050.[50] The German energy transition has significant implications for the power sector, as reflected in the following table, which represents Germany's quantitative interim and 2050 targets relating to the power sector.[51]

As discussed in Sections 8 and 9, these goals are being implemented through targeted legislation.

Targets of the *Energiewende* — Table 7

	2020	2025	2030	2035	2040	2050
Reduction in GHG emissions (compared with 1990)	40%		55%		70%	80-95%
Increase in share of RES in gross electricity consumption		40-45%		55-60%		At least 80%
Reduction of primary energy consumption (compared to 2008)	20%					50%
Reduction in gross electricity consumption	10%					25%
Share of electricity generation from CHP plants	25%					
Reduction of energy use in transport sector (against 2005)	10%					40%

BMWi, 2014a, p. 4.

48 BMWi, 2014, p. 4.

49 European Commission, n.d.

50 BMUB, 2011.

51 For targets related to other energy sectors, see BMWI, 2014a, p. 4.

8 Renewable Energy

Under the European Renewable Energy Directive, Germany has been allocated an 18 percent target for the share of gross final energy consumption to be met by renewable energy by 2020.[52] This target has been incorporated into the German *Energy Concept* targets. In line with the *Energiewende*, the German Renewable Energy Act (EEG) further specifies a target for renewable energy from electricity: 40–45 percent by 2025, and 55–60 percent by 2035.[53]

Under the EEG, the main support mechanism for renewable energy in Germany used to be the FiT, which has been in place since 2000[54] and provides a fixed price for power produced from renewable sources. The FiT is set for a 20-year term, varies by technology, and the tariff level is set at regular intervals. The cost of the FiT is covered through a surcharge on end-use customer electricity bills, as described in Section 5 of this report.

In 2014, the Renewable Energy Act was amended, with the goal of continuing progress towards Germany's renewable energy targets, while controlling cost. The amendments to the Act set quantitative targets for renewable energy, by resource, and established new FiT levels for each technology. Importantly, the 2014 amendments shift renewables support from a traditional FiT to a mandatory "Feed-in-Premium" scheme. That is, instead of receiving the FiT amount directly, all new installations larger than 500 kW (and larger than 100kW after 2016) will need to sell the electricity they produce, themselves or through a third party, and will then be rewarded the difference between the FiT and the revenues earned on the wholesale electricity market ('direct marketing').

The quantitative targets for renewable energy are as follows:

→ Wind onshore: additional 2,500 MW/year (net)
→ PV: additional 2,500 MW/year (gross)
→ Wind offshore: 6,500 MW by 2020
→ Biomass: additional 100 MW per year (gross)[55]

Notably, these targets reflect a reduction in ambition for offshore wind and biomass, due to their high costs compared to other renewable resources. The FiT levels from August 2014 have been adjusted as documented in table 8.

It is important to note that the law introduces flexible caps ("breathing cap") to reach the annual renewable energy targets. If targets are met in a given year, the following year's FiTs for that technology will be reduced by a standard rate. If targets are exceeded, the incentives will decrease, and the more they are exceeded, the greater the decrease in FiTs. Conversely, if the target is not met, the FiT will not decrease but might even increase.[56]

Thanks in large part to the German FiT scheme, Germany has seen a significant rise in the share of electricity generated by renewable resources for more than a decade.

It is important to note that a significant change to the Renewable Energy Act is expected in 2016. In order to comply with new EU environmental state aid guidelines, Germany will introduce auction schemes for renewable energy in 2016, to enter into effect in 2017.[57] It is foreseen to open a certain portion of totally auctioned capacity for assets in other countries as long as physical transmission can be guaranteed.

52 Directive 2009/28/EC.

53 This is in line with the 35 percent target for 2020 and 50 percent target for 2030 listed in Figure 18.

54 In fact, the introduction of the feed-in tariff in Germany dates back to 1991when the Stromeinspeisegesetz, the predecessor of the EEG, was adopted.

55 Agora Energiewende, 2014a.

56 Agora Energiewende, 2014a, p. 2.

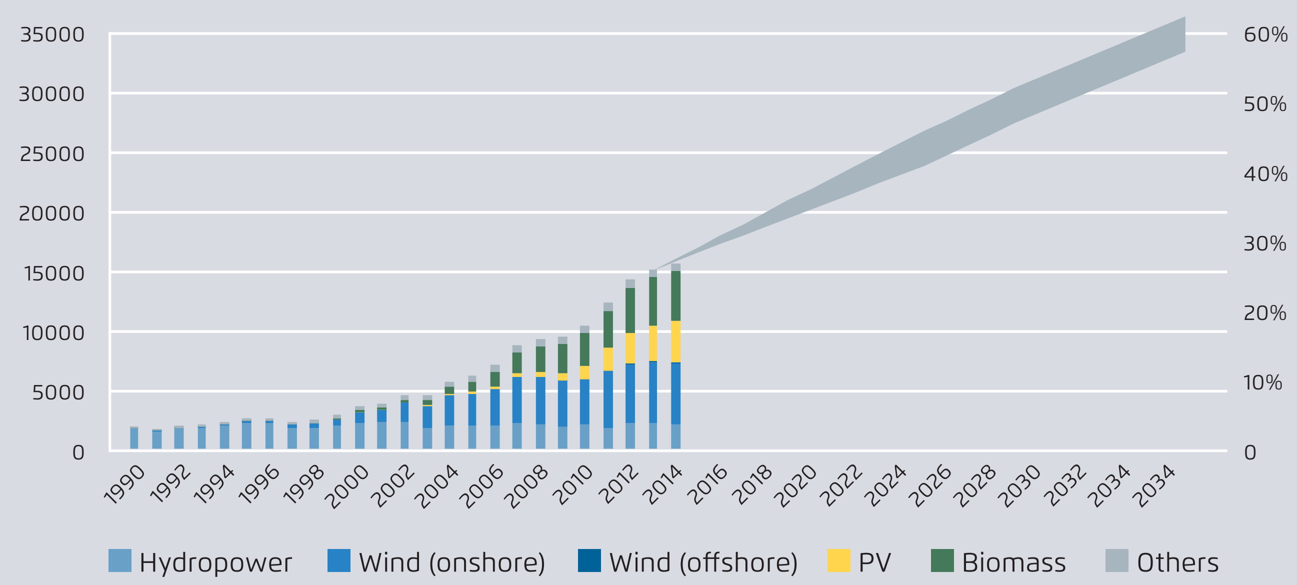
57 Agora Energiewende, 2014a.

FiT Levels under German Renewable Energy Act, from August 2014 — Table 8

Technology	Feed-in tariff level	Annual degression
Wind onshore	8.9 ct/kWh (initial feed-in tariff for at least 5 years). 4.95 ct/kWh (basic feed-in tariff).	0.4% on a quarterly basis (degression may increase up to 1.2% or decrease up to zero – depending on amount of installed capacity.
Photovoltaics	9.23 ct/kWh to 13.15 ct/kWh, depending on capacity size.	0.5%/month (degression may increase up to 2.8% or decrease up to zero – depending on amount of installed capacity.
Biomass/biogas	5.83 ct/kWh to 23.73 ct/kWh, depending on specific technology and capacity size.	→ 1.5% on an annual basis for landfill gas, sewage treatment gas and mine gas. → 0.5% for biomass on a quarterly basis (flexible cap: degression of 1.27% if annual gross increase > 100 MW).
Wind offshore	15.4 ct/kWh (initial feed-in tariff at least 12 years). 3.9 ct/kWh (basic feed-in tariff).	Degression of initial feed-in tariff: → of 0.5 ct/kWh in 2018, → of 1.0 ct/kWh in 2020, → by 1.0 ct/kWh annually from 2021.
Hydropower	3.5 ct/kWh to 12.52 ct/kWh, depending on capacity size.	0.5 % on an annual basis.

Agora Energiewende, 2014a.

Electricity supply from renewable sources, 2000–2014, and prospective supply 2015-2020 — Figure 14



BMWi, 2014d., Öko-Institut 2014

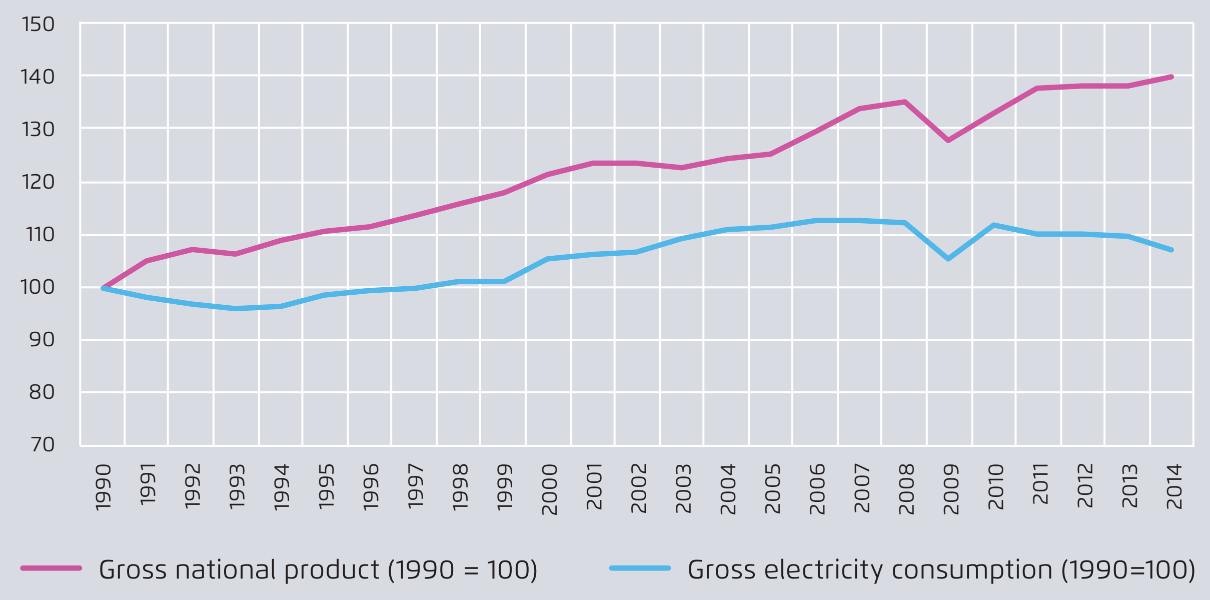
9 Energy Efficiency

Under the *Energy Concept*, Germany has set the goal of reducing primary energy consumption by 20 percent by 2020, and 50 percent by 2050 (compared with 2008). This is in line with the European goal of reducing primary energy consumption 20 percent by 2020 Europe-wide. Germany further aims to reduce gross electricity consumption by 10 percent by 2020 and 25 percent by 2050.[58] While the country has a number of policies and measures in place to support energy efficiency, and has achieved steady energy savings over time, it is not enough. The Second Monitoring Report, which tracks progress on the *Energiewende*, emphasizes that Germany must do more if it is to meet its goal of achieving 20 percent primary energy savings by 2020.[59]

One of the main instruments to achieve energy savings in Europe to 2020 is Article 7 of the European Energy Efficiency Directive. Article 7 sets mandatory end-use energy savings targets for Member States of 1.5 percent each year from 2014 to 2020.[60] This target can be met through implementation of an energy efficiency obligation on all energy distribution companies or all energy service providers, or through equivalent alternative measures.

In December 2014, the federal government has adopted a *National Action Plan Energy Efficiency* that proposes a large set of instruments ranging from competitive tenders to tax exemptions for building renovations. Some measures need legislative decision, others can be implemented directly.[61]

Energy productivity in Germany, 1990 - 2013 — Figure 15



AG Energiebilanzen, BMWi

58 BMWi, 2014a, p. 4.

59 BMWi, 2014a, p. 8.

60 However, because of available exemptions and the possibility that the transport sector can be excluded from the energy savings target, the target is closer to 0.75 percent energy savings per year.

61 BMWi, 2014e.

10 Grid Infrastructure and Reliability

10.1 Generation Adequacy Standard

Currently, the German power system has a surplus of capacity, though due to the stepwise phase out of nuclear capacity, some challenges might arise in near future in Southern Germany.[62]

In addition to the nuclear phase out, some conventional capacity will be retired in the coming years (see above, chapter 3.5. for more details). Although several GW new coal and gas plants are currently under construction, experts expect potential shortages to arise in the next decade. If the current market design is suitable to incentivise new resources able to meet peak demand and thus to avoid power shortages in the 2020s, is currently disputed in Germany. In autumn 2014 the government is launching a discussion process on potential market reform – including a debate about an improved energy-only market and capacity remuneration mechanisms as well.

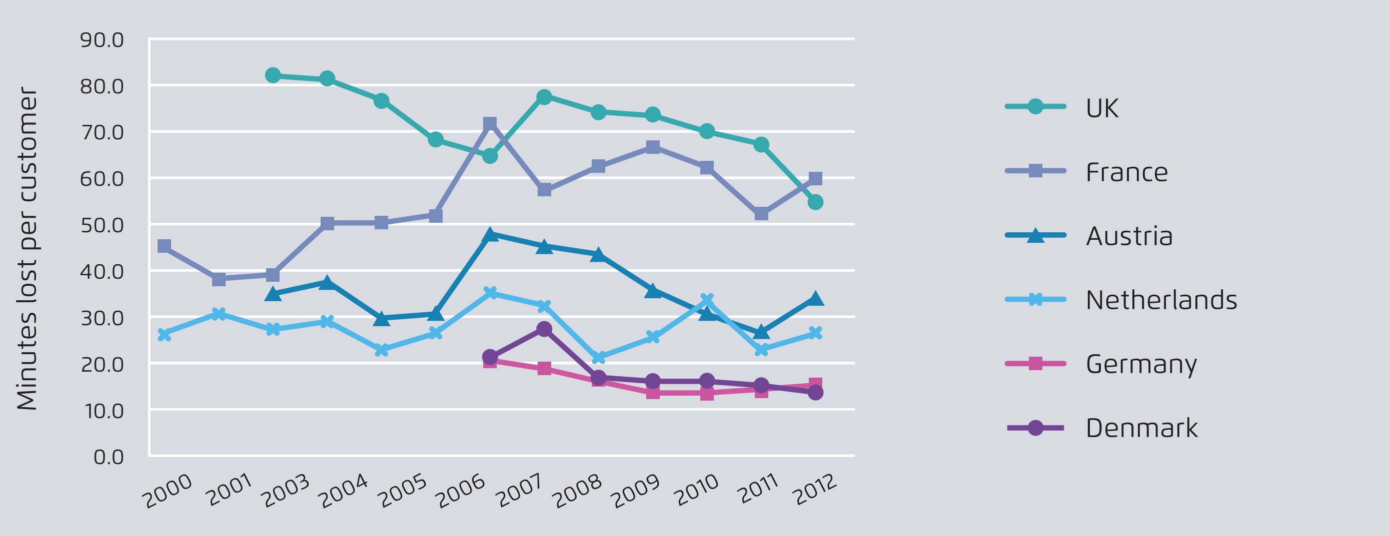
10.2 Current SAIDI

SAIDI, or the System Average Interruption Duration Index, is a standard measure of the average number of minutes of service interruption per customer on the low-voltage network in a given year. Figure 16 reflects SAIDI in six member states, including Germany, and accounts for unplanned interruptions, excluding exceptional events. As this figure indicates, reliability of service in Germany is high compared to neighbouring countries, ranging from about 14 to 21 minutes of interruptions annually per customer over the past eight years, with an overall gradual improvement over time.

10.3 Smart Metering

Germany has taken several steps towards increasing the penetration of "smart meters" in the country. As described in this section, the definition of "smart meter", and functionalities associated with smart meters, has evolved in

SAIDI—unplanned interruptions, excluding exceptional events **Figure 16**



CEER, 2014.

62 ENTSO-E, 2014b, p. 47.

parallel to European requirements regarding "intelligent" or "smart" metering systems.

The German Energy Industry Act requires installation of "measurement systems" for three categories of end users:

- 1. New buildings or those undergoing a major renovation as defined by Directive 2010/31/EC on the Energy Performance of Buildings
- 2. For final consumers with an annual consumption greater than 6,000 kWh
- 3. For plant operators under the Renewable Energy Act or power-heat coupling law for new plants with an installed capacity of more than 7 kW[63]

A measurement system is defined as a device connected to a communications network measuring device for detecting electrical energy, which reflects the actual energy consumption and actual time of use. Installation of measurement systems for these customers is only required if "technically feasible." Technical feasibility is met if measurement systems that meet the statutory requirements are available on the market.

In all other buildings, the act calls for installation of measurement systems as far as is technically *and economically* feasible. Economic feasibility is defined as replacement at no extra cost to the consumer, or as established by an economic evaluation of the BMWi.

In 2013, BMWi released a cost-benefit analysis, prepared by Ernst & Young, to determine the cost-effectiveness of installing "smart meters" in Germany under Annex I of the Electricity Directive.[64] The analysis concludes that for the first three groups of end users delineated in §21(c) of the EnWG, installation of smart meters is cost-effective and therefore recommended. For small consumers, the analysis recommends replacement of current meters with "intelligent" meters within the normal replacement cycle for meters.

The distinction between "smart" and "intelligent" meters made in the Ernst & Young report is that "smart" meters communicate information on energy consumption and time of use to energy companies, while "intelligent" meters show end users their actual energy usage via an in-home display, but do not communicate this information to the utility.[65] The report also notes that intelligent meters are easily upgraded to smart meters.

As of 2013, about 500,000 meters had been installed in Germany.[66] A number of barriers currently exist, however, to installation of smart meters as required by law. Firstly, meters have not yet been developed that comply with new security standards.[67] Secondly, the Ernst & Young recommendations have not yet been incorporated into a national roll-out strategy for smart meters. And Thirdly, German law allows third parties (that is, companies independent of the DSOs, who are the default option) to serve as metering operators and metering service providers. The DSO is required to allow the metering service provider to install

63 EnWG, Section 21(c).

64 The Electricity Directive sets the indicative goal of equipping 80 percent of consumers with "intelligent" by 2020. While "intelligent meters" are not defined in the Directive, the European Communication on Smart Grids (SEC/2011/463 final), references the Smart Grid Task Force's definition of smart meters: "Meter with extra functionality allows the meter to collect usage data and transmit this data back to the via the AMI (Advanced Metering Infrastructure). Load control and tariff management are also examples of possible extra functionality. The Smart Meter has provisions for a consumer interface that enables the consumer to monitor energy usage. See European Commission Task Force for Smart Grids, 2010, p. 43.

65 Further explanation on the functionality of smart meters and smart metering systems in Germany can be found in BSI, 2014.

66 SmartRegions, 2013, p. 47.

67 BSI, 2014.

their own devices, so long as the devices fulfill regulatory requirements. [68] However, customers cannot be bound by a metering contract for more than 3 years.

68 SmartRegions, 2013, p. 45.

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