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Energie wende
Switch to the Future

Sixth "Energy Transition" Monitoring Report

The Energy of the Future

Reporting Year 2016

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Content

Central messages from the Sixth Monitoring Report

The German energy transition is embedded in the European energy transition, which has set ambitious goals for 2030 and beyond. In particular, the package of measures titled “Clean Energy for All Europeans” will provide a new European legislative framework for clean energy. The integrated National Energy and Climate Plans to be created by EU Member States will provide information on how they plan to achieve their respective national energy and climate goals for 2030, and thereby contribute to corresponding goals of the Energy Union. The facts and figures presented in this report regarding Germany’s progress toward fulfilling several specific 2020 goals indicate the seriousness of this challenge. The coalition agreement between the CDU, CSU and SPD paves the way for implementing the necessary framework.

On the positive side, almost one out of every three kilowatt hours was produced with renewable energies, which provided 31.6% of gross electricity consumed in 2016. This increase continued in 2017. At the same time, the 2017 Renewable Energy Sources Act introduced a paradigm shift toward competitive funding rates, leading to substantially more cost-efficient development of renewable energies.

However, primary energy consumption in 2016 increased by 1.4% compared with 2015. Strong economic growth and relatively cool weather were factors. The measures proposed by the National Action Plan on Energy Efficiency (NAPE) and the energy policy resolutions of 1 July 2015 have been instigated and are starting to show results. However, annual energy savings of 0.8% on average since 2008 are not sufficient to reach the target set for 2020 (20% reduction). Overall, there is a great need to take action to achieve the reduction target as quickly as possible.

Energy consumption in buildings in 2016 increased by 4.3% compared with 2015. Since 2008, this figure has declined by an average of around 0.8% annually. In order to achieve 20% savings by 2020, consumption would have to decline five times this amount in the five remaining years. Here, too, much work must be done to reach the target as quickly as possible.

Final energy consumption in the transport sector continued to run counter to the goals of the Energy Concept, increasing by around 2.9% compared with the previous year and around 4.2% compared to 2005. It is expected that the 2020 Goal (reduction by 10%) will not be reached until around 2030 under the present circumstances. Considerable additional efforts will be required to turn this trend around as soon as possible.

Greenhouse gas emissions increased slightly in 2016, but have dropped by 27.3% overall compared with 1990 levels. The Federal Government will continue to implement the 2020 Climate Action Programme, assess its effects on lowering emissions, and determine what additional action should be taken in order to reach the climate protection goal for 2020 (40% less greenhouse gases compared with 1990) set forth in the coalition agreement between the CDU, CSU and SPD.

Germany's electricity supply is secure. There is enough energy to cover demand in Germany at any time, guaranteeing a high level of supply security. The European electricity market also contributes to this security. Germany is also at the forefront – also by international standards – with supply quality consistently at a very high level.

Cost efficiency is one of the main criteria for optimal implementation of the energy transition. In light of this, efforts have been made to slow down the electricity cost dynamics of previous years appreciably. Whereas electricity prices increased in 2016 by an average of 2.4% for household customers, prices in 2017 were approximately at the level of the previous year. For industrial customers not covered by special compensation arrangements, electricity prices fell by 4.0% in 2016.

Final consumer expenditures for final energy consumption dropped in 2016 from €215 billion to €212 billion. The share of final consumer expenditures in the nominal GDP declined on the previous year from 7.1% to 6.7%. The share of electricity costs in GDP declined to the lowest level since 2010. In 2016, energy costs from the use of imported primary fossil fuels were down on the previous year, falling from €54.8 billion to €45.9 billion. This was mainly a result of lower prices on the global commodity markets, which again fell substantially over the previous year.

If the energy transition is to be successful, renewable energies and electricity grid capacity must be better synchronized – also at the regional level – grid expansion must be accelerated and existing grids must be modernized and optimized. The grid expansion measures that have been agreed must be implemented without delay. Just as important is implementing the projects under the Federal Requirements Planning Act as quickly as possible. This process has entered the next phase, as federal planning has commenced for the big extra-high voltage, direct current transmission lines SuedLink and SuedOstLink in 2017, and for A-Nord in early 2018.

The energy transition is part of a macroeconomic modernisation strategy that will trigger extensive investments in the German economy. Innovative business models offer big opportunities in this process. The energy transition is beneficial in opening up new opportunities for innovation and new market potential. Digitisation of the energy transition also has an impact. Many German companies profit from trade in new and innovative energy technologies. In 2016, exports of renewable energy installations and components amounted to almost €12 billion. International energy collaboration efforts are gaining in importance, because they facilitate political discussions and underpin economic activities.

1 Introduction

The Energy for the Future monitoring process tracks progress towards goals and checks the implementation of measures to transition the energy system with a view to establishing a secure, economic and environmentally friendly energy supply; the German energy transition is embedded in the European energy transition and its ambitious goals (see Chapters 2 and 3). The monitoring process provides the basis for making adjustments, if necessary. The focus is on three tasks:

Overview: The monitoring process provides a fact-based overview of the current status of progress with regard to implementation of the energy reforms. It condenses the reams of statistical information on energy that have been collected into selected indicators.

Evaluation: Based on the status quo, the annual monitoring reports analyse to what extent targets set out in the Federal Government's Energy Concept are being met and what effect the measures are having. In areas where the targets are likely to be missed, consolidated progress reports comprising several years of data propose measures to remove obstructions and reach the targets.

Outlook: The monitoring process also looks ahead to the likely development of key indicators. To this end, the progress reports capture and visualise reliable trends.

This Sixth Monitoring Report documents the status of the energy transition in 2016, and assesses the progress made toward reaching the goals. At the heart of the monitoring process for the energy transition is the annual monitoring report, which provides new facts and figures about the energy transition. The structure of the current report and the topics addressed are based on the energy transition target architecture adopted by the Federal Government in December 2014.

Embedded in the European and international context (Chapter 3), Part I summarises current progress towards the quantitative goals of the energy transition in the following areas:

- Progress in the expansion of renewable energy (Chapter 4)
- Development of energy consumption and energy efficiency (Chapter 5) with a specific focus on the three areas of electricity, heating and transport
- Energy policy targets and measures in the buildings sector (Chapter 6) and in the transport sector (Chapter 7)
- Development of greenhouse gas emissions (Chapter 8)

Part II looks at other targets and policies affecting the energy transition:

- Development of the power plant fleet with regard to security of supply, the nuclear phase-out and compatibility with the energy transition (electricity market 2.0) (Chapter 9)
- Affordability of energy for private households and businesses (Chapter 10)
- Environmental compatibility of the energy supply system (Chapter 11)
- Expansion of the electricity transmission systems and distribution grids (Chapter 12)
- Integrated development of the energy system with a view to sector coupling and digitisation (Chapter 13)
- Energy research and innovation (Chapter 14)
- Correlation of the energy transition with investment, growth and employment (Chapter 15)

A table at the end of the Report provides an overview of the status of implementation of related measures (Chapter 16). A list of abbreviations is also included.

A commission of independent energy experts oversees the monitoring process. Working on a scientific basis, the commission of experts comments on the Federal Government's monitoring and progress reports. Prof. Dr. Andreas Löschel (University of Münster) is the chair of the commission. Other members are Prof. Dr. Georg Erdmann (Technical University of Berlin), Prof. Dr. Frithjof Staiß (Centre for Solar and Hydrogen Research) and Dr. Hans-Joachim Ziesing (Working Group on Energy Balances). The opinions of the commission of experts are published on the website of the Federal Ministry for Economic Affairs and Energy, together with the monitoring reports and progress reports.

By making the energy transition more transparent, the monitoring process helps boost public acceptance for it. The Federal Government publishes central data on the energy transition in regular reports. Dialogue with the commission of experts and the high-level energy transition platforms that focus on the electricity market, energy efficiency, buildings, energy grids and research and innovation promotes exchange with representatives from the Länder, the business community, society and academia. Common solutions and strategies for the central action areas of the energy transition can be developed in this way.

In addition, the Federal Government has also been reporting on current greenhouse gas emission trends since 2015 in annual climate reports. The report provides information on the state of implementation of measures defined in the 2020 Climate Action Programme, current trends and the effects of emissions reduction.

2 Objectives of the energy transition and monitoring indicators

By pursuing the energy transition, Germany is heading towards a future with a secure, economic and environmentally friendly energy supply. The orientation for the energy transition – and thus the basis for its monitoring – is provided by the Federal Government's Energy Concept, further decisions by the Bundestag, and European rules. National goals are based on the ambitious goals set at the EU level. The triple objective of security of supply, affordability and environmental compatibility remains the guiding principle for Germany's energy policy, as is evidenced by the coalition agreement between the CDU, CSU and SPD.

Table 2.1: Goals at the European and international level

Europe International	Creating a reliable European and international framework for more climate protection, renewables and energy efficiency.

Table 2.2: Quantitative targets of the energy transition and status quo (2016)

	2016	2020	2030	2040	2050
Greenhouse gas emissions					
Greenhouse gas emissions (compared with 1990)	-27.3%*	at least -40%	at least -55%	at least -70%	largely greenhouse-gas-neutral -80% to -95%
Renewable energy					
Share of gross final energy consumption	14.8%	18%	30%	45%	60%
Share of gross electricity consumption	31.6%	at least 35%**	at least 50% Renewable Energy Sources Act 2017: 40–45% by 2025**	at least 65% Renewable Energy Sources Act 2017: 55–60% by 2035	at least 80%
Share of heat consumption	13.2%	14%			
Efficiency and consumption					
Primary energy consumption (compared with 2008)	-6.5%	-20% → -50%			
Final energy productivity (2008–2050)	1.1% per year (2008–2016)	2.1% per year (2008–2050)			
Gross electricity consumption (compared with 2008)	-3.6%	-10% → -25%			
Primary energy consumption in buildings (compared with 2008)	-18.3%	→ -80%			
Heat consumption in buildings (compared with 2008)	-6.3%	-20%			
Final energy consumption in the transport sector (compared with 2005)	4.2%	-10% → -40%			

Source: In-house data from the Federal Ministry for Economic Affairs and Energy, March 2018
* Provisional figure for 2016
** The Coalition Agreement between the CDU, CSU and SPD provides for additional expansion of renewable energy that is effective, efficient, synchronized with energy grids and increasingly competitive. With these requirements in place, the goal is a 65%-share of renewables by 2030; any corresponding adjustments will be made. Special tenders in the area of wind and solar energy aim to help reach the 2020 climate protection goal. The challenge is to better synchronise renewables and grid capacity expansion.

Table 2.3: Targets and policies affecting the energy transition

Security of supply	Efficiently covering Germany's energy needs at all times.
Nuclear energy phase-out	Switching off the last nuclear power plants at the end of 2022.
Affordability **Competitiveness**	Maintaining affordability of energy and ensuring Germany's competitiveness.
Environmental aspects	Creating an energy supply system that is environmentally compatible and protects natural habitat.
Grid expansion	Expanding and modernising grids to meet demand.
Sector coupling **Digitisation**	Unlocking the potential of efficient sector coupling and digitisation for a successful energy transition.
Research **Innovation**	Fostering forward-looking innovations for the restructuring of the energy supply.
Investment **Growth** **Jobs**	Retaining and creating jobs in Germany and laying the foundations for sustainable prosperity and quality of life.

Source: In-house data from the Federal Ministry for Economic Affairs and Energy, March 2018

EU goals are described in detail in Chapter 3. The current status of negotiations stipulates that by 2030, greenhouse emissions across the EU should be reduced by at least 40%, renewable energies should reach a share of at least 27% in gross final consumption of energy, and European primary energy consumption should be reduced by 30% (see Chapter 3).

Part I of the Monitoring Report examines the quantitative targets of the energy transition. As Table 2.2 shows, these targets extend through to 2050, with some milestones set for 2020, 2030 and 2040.

Part II of the Monitoring Report looks at other targets and policies affecting the energy transition. As quantitative targets have not been agreed for some of these topics, these areas also focus on qualitative targets (Table 2.3). Public and scientific community debates revolve around how well the goals of supply security and affordability can be quantified and if it is possible to verify which goals have been reached using key indicators (see ETC 2017). Any efforts are welcome that use a multidimensional approach to help make the status of the energy transformation more visible. However, there has been no real consensus as of yet regarding quantification of the specific targets. For this and other reasons, Part II uses not just one indicator or a leading indicator, rather several to examine the targets – taken together, they provide a reasonable picture of progress made toward these goals and demonstrate the complexity of the issues involved.

In 2016 the Federal Ministry for Economic Affairs and Energy commissioned a research project titled "Definition and Monitoring of Supply Security in European Energy Markets 2017–2019". Researchers define reliable indicators and thresholds that help monitor and assessing the security of supply in the electricity market (see Chapter 9).

2.1 Target architecture for the energy transition

The target architecture structures the individual goals of the energy transition. The Cabinet adopted a target architecture for the energy transition with the First Energy Transition Progress Report (see Diagram 2.1). This target architecture structures and prioritises the individual goals of the Energy Concept, distinguishing between multiple goal levels:

The **policy goals** define the framework for the restructuring of our energy supply and comprise:

- climate targets, including a 40% reduction in greenhouse gas emissions by 2020 and thereafter,
- the phase-out of nuclear energy for electricity generation by 2022, and
- goals to guarantee competitiveness and security of supply.

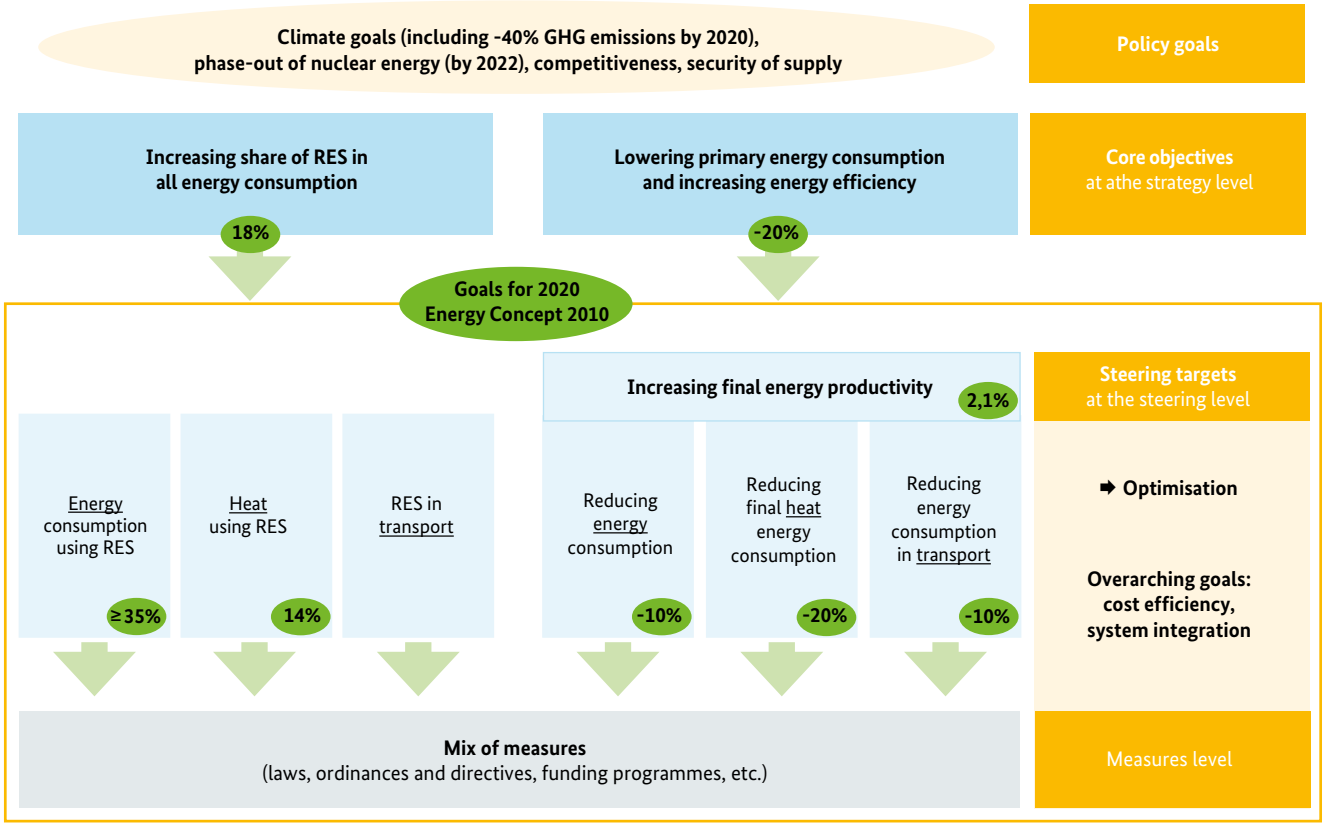
The **core objectives** describe the central strategies of the Energy Concept to drive the energy transition forward. The focus here is on expanding renewables and reducing primary energy consumption or increasing energy efficiency. Both core objectives are defined in concrete terms with steering targets for the three action areas of electricity, heating and transport. The **steering targets** and the **corresponding measures** are aligned so that, with an integrated approach, the overarching goals can be achieved in the most reliable, cost-effective manner possible.

2.2 Indicators and evaluation scheme

Energy transition monitoring is based on publicly accessible and verifiable data. The process is carried out using selected indicators which visualise progress made in the energy transition over time. These indicators are informed, wherever possible, by official and publicly accessible data. The Energy Statistics Act is the national legal basis for official energy statistics, which was amended in March 2017 to adapt it to the current situation. However, surveys for 2017 were conducted in accordance with the original Act. The indicators used for the various topics are illustrated in Diagram 2.2.

A points system is used to assess the progress made in terms of the quantitative targets of the energy transition. Firstly, the development of the indicators since 2008 is extrapolated on a linear basis. On the basis of percentage deviations of the extrapolated figures from the target figures in 2020, points are awarded as follows for this report: 5 points if, according to the extrapolation, the target is met or the deviation is less than 10%; 4 points if the deviation is between 10 and 20%; 3 points if the deviation is between 20 and 40%; 2 points if the calculated deviation is between 40 and 60%; and 1 point if the deviation from the target exceeds 60%. The evaluation scheme applied here cannot replace complex, model-based forecasts. But this system offers the advantage of a comparatively simple and comprehensible depiction of the current status of key energy transition indicators at a glance. The future impact of measures which are currently being implemented is not reflected in this assessment of whether targets are met. They may yet have an impact, and the actual development can deviate in response to political and economic influences. Therefore, such an assessment always carries a certain degree of uncertainty.

Diagram 2.1: Structure of the goals of the Energy Concept



Source: In-house data from the Federal Ministry for Economic Affairs and Energy, 10/2016

Results from models created for the "Target Architecture Study" (Effects of Measures taken by the Federal Government within the Target Architecture for Restructuring the Energy Supply) conducted by the Federal Ministry for Economic Affairs and Energy. The study is set up as a meta-analysis and will assess the effects of instruments in the target architecture up to 2020 as compared with a reference situation. By comparing a time corridor for projected effects with the target values for 2020, the study estimates to what extent goals can be reached when the additional effects of measures already underway are factored in until 2020. The Federal Government does not take ownership of the results of this study; however, it does include them in its assessments of progress toward the goals.

The methodology of the study Effects of Measures taken by the Federal Government within the Target Architecture for Restructuring the Energy Supply

This study used a meta-analysis to assess the effects of measures taken for the target architecture. Available surveys on the effects of political instruments and strategies were analysed, using models and assumptions such as the GDP and population growth. This method can lead to deviations from key indicators which form the basis for more current estimates and calculations. The study defined ranges for quantifying the estimated effects in order to take into account prevailing uncertainty regarding the effectiveness of the instruments and if necessary, to be able to draw additional conclusions on how well targets are being fulfilled. Wherever data was missing, estimates were used.

The study quantified effectiveness of instruments for the period between 2008 and 2020. The policy goals of the target architecture served as guidelines. The transport sector part of the study commenced in 2005. The survey results provided quantification of general instrument effectiveness on the basis of a suitable activity size (number of cases, funds paid out) and specific savings effects (per activity), from which the absolute savings amount can be derived. The Target Architecture study assessed the instrument effectiveness on this basis as annual, cumulative effects. The study indicated the specific target amount for 2020 on the basis of the respective base year. The next step was to extrapolate the individual contributions to the higher-level primary energy consumption and greenhouse gas goals. This was done on the basis of primary energy consumption and CO_2 emission factors that were used in quantifying the immediate actions of NAPE (see Chapter 5.4). The study took what is called the counterfactual scenario from the GWS and Prognos Study (2018) and adapted it to determine the development of the reference figures for quantifying the effectiveness of the measures.

To ensure comparability of various studies of effects of instruments conducted in the context of the Target Architecture Study, the study applied uniform test criteria. These include instrument design, the methods used for detecting energy savings, the time period during which the measure was effective, the reference trend on which it was based and the extrapolation methods. In rare cases, the authors of the study used their own estimates on effectiveness on the basis of a bottom-up assessment.

Range – to measure the effectiveness of the measures, the study defined a range of minimum and maximum effect for each measure. These ranges include all results of the surveys, which to some extent vary widely. In addition, the study specified an estimated value within the range, that represents the most realistic effect of the respective measure in the opinion of the authors of the study. In determining this estimate, it is particularly relevant to ask how realistic the timescale for implementation is. How plausible are the assumptions on the effects of the instrument and the method of calculation? Numbers used for the effectiveness range were comparable the test criteria of the study as a basis.

The results of the study on target progress are depicted in Part I of the Monitoring Report as part of the results of the points system. Unlike the study, the points system for 2017–2020 includes the effectiveness of the measures as part of a linear extrapolation. This does not factor in the possibility that the effect of the measures can increase exponentially over time.

The expert commission of the Energy for the Future monitoring process presented a short commentary on the status of the energy transition as part of an inventory of the current situation. The commission expects Germany to reach the targets on increasing the share of renewables in gross final energy consumption or in gross electricity consumption. However, the expert commission deems that other quantitative goals – reducing greenhouse gases, primary energy consumption and renewables and consumption targets for the transport sector – will probably not be reached, or it is uncertain, especially regarding the increase of the share in renewables in heat consumption and reduction of heat demand in the buildings sector (EWK 2017).

The figures indicated in this Report generally reflect the data available in March 2018. The data on the Energy of the Future monitoring process are publicly accessible on the websites of the Federal Ministry for Economic Affairs and Energy and the Federal Network Agency. The year under review is 2016, but where some of the data is preliminary, the report draws on current trends in some cases. Data on energy consumption in 2016 (Chapters 5 and 6) are based on the evaluation tables of the Working Group on Energy Balances (AGEB 2017). Because several different methods are used, some data on renewables might deviate slightly from those in other publications. With this report, the Federal Government fulfils its reporting obligations pursuant to Section 63 (1) of the Energy Industry Act and Section 98 of the Renewable Energy Sources Act, as well as with regard to the National Action Plan on Energy Efficiency (NAPE) and the Energy Efficiency Strategy for Buildings (ESG).

Diagram 2.2: Indicators*

Europe **International**	• EU targets 2020/2030 • Physical flows of electricity • Emissions trading in the EU-ETS • Effort sharing in areas outside the emissions trading scheme • Global investment in renewable energy and energy efficiency • Global CO_2 emissions • Global installed renewable capacity
Renewable energy	• Share of renewable energy sources (RES) in gross final energy consumption • Share of RES in gross electricity consumption • Renewable electricity generation by technology • Gross electricity generation by energy source • Share of RES in heating and cooling consumption • Share of RES in the transport sector • EEG surcharge by technology • Sum total of EEG surcharge plus electricity prices on the exchange

Efficiency and consumption	• Primary energy consumption • Primary and final energy productivity • Gross electricity consumption
Buildings	• Share of final energy consumption of buildings in total energy consumption • Final energy consumption of buildings/heating final energy consumption • Specific final energy consumption for space heating • Primary energy consumption in buildings
Transport	• Final energy consumption in the transport sector • Specific final energy consumption of the transport sector • Number of 3-wheel-plus vehicles with an electric drive • Number of 3-wheel-plus vehicles powered by fuel cells and natural gas • Shift to rail transport • Shift to public transport
Greenhouse gas emissions	• Greenhouse gas emissions • Greenhouse gas emissions by source group • Energy-related CO_2 emissions by sector • Greenhouse gas emissions avoided through use of renewables • Specific greenhouse gas emissions in relation to the population and GDP
Security of supply **Nuclear energy phase-out**	• Installed capacity of power generation plants • Distribution of power plant capacity across the Länder • Combined heat and power including electricty generation • Conventional generation capacities: new plant construction and dismantling of plants • Capacity of pumped storage power stations • Nuclear phase-out roadmap • SAIDI power • Conventional power plants under construction
Affordability **Competitiveness**	• Final consumer spending on energy and as a share of GDP • Energy spending of private households • Electricity prices of private households • Energy costs for industry • Oil and gas prices • Prices of electricity on the exchange • Electricity prices of non-privileged industrial enterprises • Macroeconomic energy spending • Energy prices compared to other countries
Environmental compatibility	• Environmental monitoring of the energy transition using a suitable set of indicators (being developed)
Grid infrastructure	• Projects under the Power Grid Expansion Act and Federal Requirements Planning • Grid investments • Grid charges • Costs for ancillary services
Sector coupling **Digitisation**	• Number and electricity consumption of heat pumps • Number and electricity consumption of E-mobility • Remote controllability and remote readability of RES installations • Smart meters in private households • Smart meters in industry • Digitisation of the energy transition and the energy sector
Energy research **Innovation**	• Industry spending on R&D • Federal research spending in the Energy Research Programme • Project funding from EU funds • Patents • Market uptake of innovative technologies in energy consumption
Investment **Growth** **Jobs**	• Investment in renewable energy and energy efficiency • Investment in grids and electricity supply • Primary energy sources saved as a result of the use of renewable energy • Numbers employed in renewable energy sector • Employment in the energy sector

Source: In-house data from the Federal Ministry for Economic Affairs and Energy, 3/2018
*New in this year's monitoring report is the selection of indicators in the new Chapter 11 (Environmental compatibility of the energy supply system)

3 The energy transition in the European and international context

Where do we stand?

With regard to the targets for 2020, the EU is still on a good path. Not only the sectors included in the European Emissions Trading System (ETS), but also those not included have already fulfilled their respective targets ahead of time, of reducing emissions from 21% or 10% respectively at the EU level.

Despite progress in renewable energy sources, Germany needs additional effort, in particular in reducing greenhouse gas emissions and primary and final energy consumption, in order to comply with its obligations regarding 2020 goals for individual EU Member States.

Efforts to expand the use of renewables and improve energy efficiency are bearing fruit all over the globe, and international interest in joint projects with Germany is continuing to grow.

Diverse collaboration formats strengthen trade and exchange of electricity between Germany and its neighbours. Bilateral agreements have addressed specific issues regarding cross-border energy trade with Denmark and Austria.

What is new?

In particular, the package of measures titled “Clean Energy for All Europeans” will provide a new European legislative framework for clean energy. The integrated National Energy and Climate Plans to be created by EU Member States will provide information on how they plan to achieve their respective national energy and climate goals for 2030, and thereby contribute to corresponding goals of the Energy Union.

More effective price signals should further strengthen the ETS. The ETS reform that entered into force in April 2018 will balance a limited offer of certificates with international competitiveness of the European industry.

In the context of the European aspect of the energy transition, the Cross-Border Renewable Energy Ordinance facilitates what is called open auctions that enable projects in other EU Member States to receive a contract. The Federal Government introduced this option not only for ground-mounted PV installations but also for onshore wind installations.

During the German presidency the heads of state and government of the G20 resolved a G20 Action Plan on Climate and Energy for Growth, that also recognized the benefits of an international monitoring process.

Europe **International**	Creating a reliable European and international framework for more climate protection, renewables and energy efficiency.

3.1 European energy policy

The EU is generally on target for 2020. Regarding the goals it has set itself – reduction of GHG emissions by 20% (over 1990), a share of renewable energy sources in the energy supply of 20%, and reduction of primary energy consumption by 20% (compared with a reference trend) – the EU is either already very close or has reached these goals ahead of time in some areas (Diagram 3.1). However, there is very little time left to reach all of the targets. For example, there is a need for action regarding increasing the share of renewables in the transport sector or regarding the annual energy savings in some of the Member States.

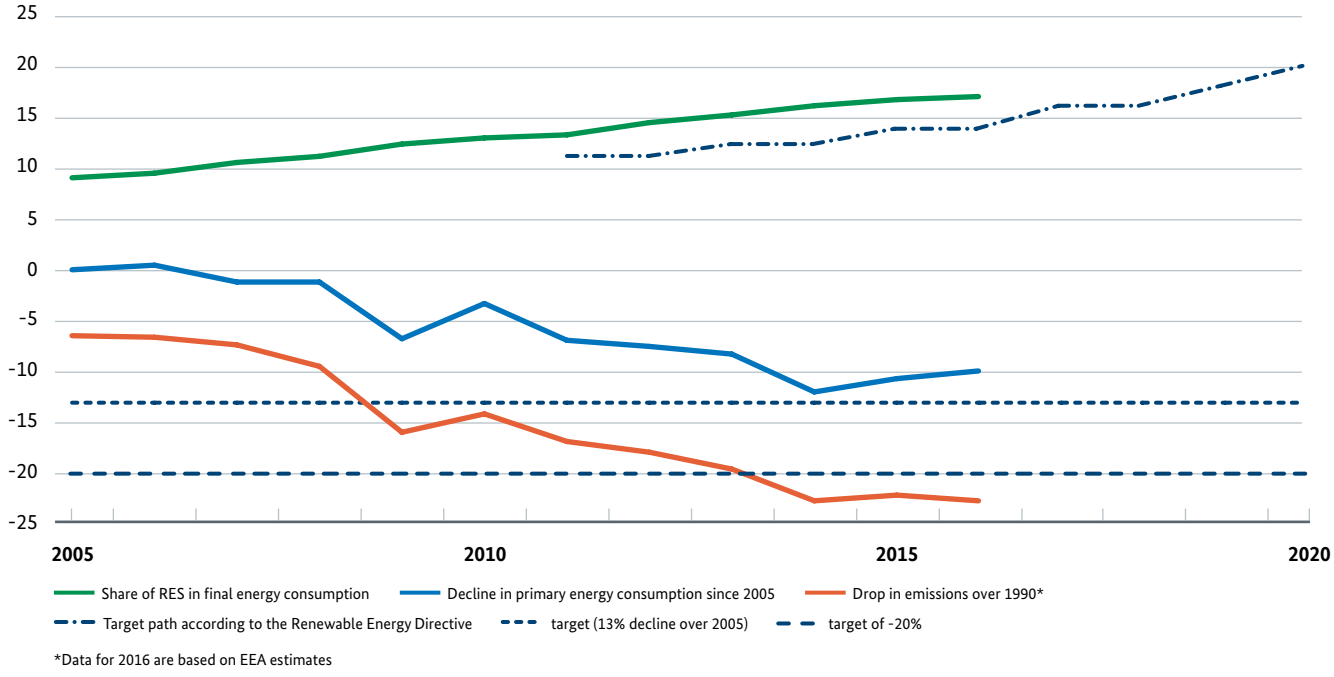
The situation regarding reduction of greenhouse gases is positive. In 2016, emissions were almost 23% down over 1990, according to EEA estimates. This exceeds the 20% target that the EU agreed on in the Framework Convention on Climate Change of the Kyoto Protocol. The short-lived slight increase in 2015 did not continue, so that the 2020 target is no longer at risk.

The EU-wide share of renewables in gross final energy consumption is not far from the 20%-mark. In 2016, this figure was at 17% throughout the EU, which is a substantial contribution to decarbonising the energy system in Europe. Accordingly, a large majority of the Member States reached or exceeded their indicative goals under the EU Renewable Energy Directive. This is also true for Germany, which had an indicative targeted 2015/2016 average of a 11.29% share of renewables in gross final energy consumption. Germany's actual figure was 14.7% (calculated using EU methods). Renewables were even at a nearly 30%-share in all of the EU, with a rising tendency. In particular, wind energy and photovoltaic has developed strongly since 2005.

Further efforts must be made in the transport sector in particular. In 2016, the EU-wide use of renewables in the transport sector was at 7.1% – quite far from the sector target of 10% for 2020.

The EU has made noteworthy progress in energy efficiency in recent years. The period between 2005 and 2016 saw a decline in primary energy consumption of 10% overall and in final energy consumption of 7%. The lower energy intensity in the economy in all of the EU was one factor in this drop. However, both in 2015 and 2016 primary energy consumption went up slightly, due to the relatively cool winter and lower fuel prices compared to the previous year. In 2016 this figure was at 4% above the 2020 target of less than 62.09 EJ – which corresponds approximately the primary energy consumption figure for Belgium. Final energy consumption was 2% over the target of less than 45.47 EJ. To reach the target, an amount of at least the final energy con-

Diagram 3.1: Progress in the EU regarding 20-20-20 targets
in Percent



*Data for 2016 are based on EEA estimates

Source: Eurostat 02/2018 (Renewables and primary energy consumption figures; primary energy consumption without non-energy consumption);
EEA 12/2017 (Emissions figures; without LULUCF, but with indirect CO_2 and with international aviation); in-house calculations

sumption of Norway would have to be saved between 2016 and 2020. Provided the growing consumption figures observed in 2015 and 2016 do not indicate a shift in trends, the EU is likely still on a good path toward reaching the 2020 targets. Nevertheless, addition efforts may be required, especially if consumption remains high.

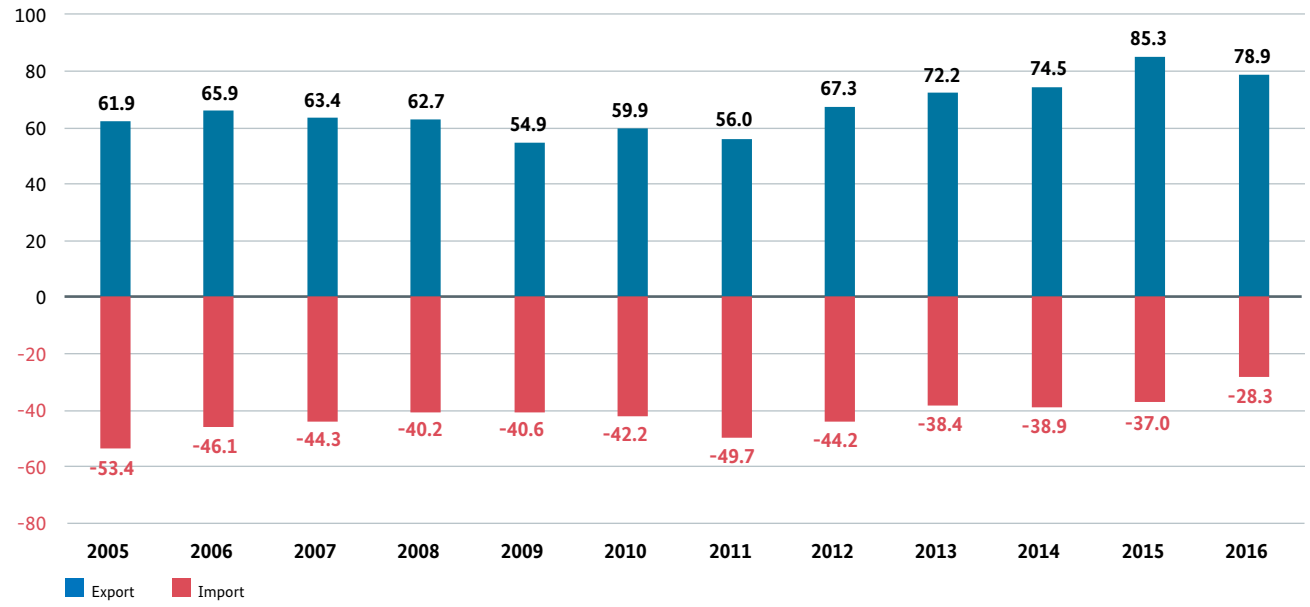
With a view to supply security, the EU considers a better-coordinated approach in the future as essential. To satisfy energy demand, the EU is particularly reliant on oil and gas imports from non-EU countries. The share of net imports in total gross domestic consumption in 2016 was at around 88% for crude oil, and 70% for gas. A large part of these imports, both oil and gas, came from Russia (almost one-third, and more than one-third, respectively). A coordinated approach toward gas supplies should include a common methodology, more transparency and stronger cross-border cooperation and support of Member States.

The European electricity market is reality, and contributes substantially to a secure energy supply. It allows for more competition on the electricity markets and as such creates affordable electricity prices for consumers in EU Member States. A well-connected electricity market is also necessary for inexpensive integration of more and more energy from renewable sources that are not equally accessible. The physical electricity exchange balance in Germany reached an all-time high in 2016, at over 50 TWh (Diagram 3.2).

A key factor for an integrated electricity market is having connecting transmission lines (interconnectors) between national electricity markets that function well. To this end, the EU has set an indicative goal for interconnection – the capacity for exchange of cross-border transmission lines – of 10% by 2020. Interconnection in 2016 and 2017 was below the 10%-level in 11 Member States. This also applies to Germany, due to the rapidly growing capacity for generating renewable energy. The rate of interconnection drops if the expansion of interconnectors cannot keep pace with the rapid expansion in renewables capacity. For this reason, the EU uses its transeuropean energy network policy to promote projects that are important for well-connected networks in all Member States. According to the EU Commission, around 30 energy infrastructure projects with a European scope have already been completed or will be completed by the end of 2018. Another 47 projects are planned for completion by 2020. These projects are aimed at helping Member States reach their interconnection goals. At this point in time, interconnectors to and from Germany have a capacity of around 17 GW and will be further expanded.

Intensive bilateral and multilateral cooperation in Europe is essential to ensure the stability of the energy supply. Germany is therefore continuing its involvement in various cooperation platforms. The goal is to develop joint measures to better integrate electricity markets, to achieve a more

Diagram 3.2: Physical flows of electricity in cross-border capacities
in TWh



Source: Working Group on Energy Balances, 10/2017

affordable supply security, and to enhance the design of the European electricity market. This includes the pentalateral Energy Forum (Penta-Forum) together with the Benelux countries, France, Austria and Switzerland, or the group of "Electricity Neighbours" initiated by Germany that includes German neighbours plus Norway and Sweden.

The amendment of the Cross-Border Renewable Energy Ordinance (GEEV) adopted in August 2016 improves cooperation with Electricity Neighbours and strengthens the German energy transition in Europe. This implements part of the overall agreement with the European Commission on state aid rules with regard to the EEG 2017. Germany accordingly agreed to open up bidding for 5% of annual capacity to be installed using renewables to installations in other EU Member States. The new GEEV now includes not only ground-mounted photovoltaic systems but also bidding for onshore wind energy installations.

Germany has met the challenge of cross-border electricity exchange together with its Electricity Neighbours, Denmark and Austria. Germany and Denmark agreed in June 2017 to gradually allow for more trade in electricity between the two countries, with the long-term goal of efficient use of cross-border transmission lines for energy trading as soon as there are no more domestic network bottlenecks. During a test phase that began in July 2017 and will extend to January 2020, minimum trade capacities are to be raised progressively to 1,100 MW using what is called countertrading. In case of shortages in Germany, the costs for these measures will paid for by the German side, and if shortages occur in Denmark, the Danes will bear the costs. Approximately 253 GWh were traded from July to November 2017 using countertrading, at a total cost of €8.15 million.

Electricity trading at the German-Danish border is also the subject of anti-trust proceedings at the European Commission. These proceedings are reviewing a commitment offer made by a German transmission system operator, TenneT. In this agreement, TenneT is offering minimum trading capacities of 1,300 MW. Germany and Austria agreed on congestion management at their mutual border; this agreement also provides for a minimum trade capacity. This enhances security of supply and limits equalization efforts on the part of the network operators, which in turn lowers costs for German consumers.

In November 2016 the European Commission introduced an extensive legislative package titled "Clean Energy for All Europeans" that aims to reshape the European energy framework by 2030. Central elements include the recommendations for a governance system for the Energy Union (Governance Regulation), for a new EU electricity market design (Electricity Market Directive, Electricity Market Regulation, ACER regulation and risk provisioning regulation) and for reworking the directives for renewables, energy efficiency and buildings. Negotiations are expected to be completed during 2018.

As negotiations stand right now, the following targets must be reached at the European level by 2030:

- greenhouse gas emission should be lowered by at least 40% (against 1990 levels; this has already been decided in October 2014 by the European Council);
- an informal consensus in the trilogue requires that at least 32% of the gross final consumption of energy must be renewable energy sources;
- as well as informal consensus in the trilogue that energy consumption must be lowered by 32.5% (compared with the forecast made in 2007 regarding energy consumption in 2030).

An additional goal is to create a 15%-level of cooperation – that means that every Member State should provide sufficient cross-border transmission lines such that at least 15% of the maximum electricity output of domestic power plants (installed generating capacity) can also be exported through these lines. However, this goal is defined more specifically with additional thresholds that address the problem that

with increasing proportions of renewable energy, the installed generating capacity is high even if actually very little power is generated, due to lack of wind or sun.

The amended Renewable Energy Directive provides for measures for increasing the share of renewable energy in the respective sectors. According to the informal agreement of the trilogue, EU Member States should be obligated to increase the share of renewables in the heat and cooling sector by 1.1% annually, starting with 2021 (1.3% if waste heat and waste cooling are included, however the share of waste heat and cooling is not to exceed 40%). Member States will commit to using fuels that will boost the share of renewables in the transport sector to 14% by 2030. In addition, the directive stipulates uniform funding rules that promote market integration of increased renewables use in the electricity supply sector.

The integrated National Energy and Climate Plans (NECP) form the core of the governance regulation. The loose agreement of the trilogue calls upon each Member State to submit a draft National Energy and Climate Plan to the

Table 3.1: Overview of major EU 2020 and 2030 targets

	2016	2020 targets	2030 targets (according to informal trialogue agreements)	Comments
GHG reduction (from 1990)	23%	at least 20%	at least 40%	binding
GHG reduction in the ETS area (from 2005)[1]	26%	21%	43%	binding
GHG reduction in non-ETS sectors (from 2005)[1]				
• for all of the EU	13.3%[2]	10%	30%	binding
• for Germany	4.9%[2]	14%	38%	binding
Renewables percentage				
• of gross final energy consumption at the EU level	17%	20%	32%	binding
in Germany	14.8%	18%	no country-specific targets	binding
• in the heating/cooling sector	13.2%		Increase of 1.1 percentage points annually (waste heat and waste cooling included: 1.3 percentage points annually)	indicative
• in the transport sector	7.1% (EU) 6.9% (Germany)	10%	14%	no sector targets, rather commitment to introduce a certain percentage to the market
Reduction of energy consumption				
• at the EU level	10% reduction in primary energy consumption from 2005	by 20%[3] (= 13% drop in primary energy consumption from 2005)	by 32.5%[3]	no information
• in the individual EU Member States		indicative national contributions to reaching targets	indicative national contributions to reaching targets	indicative
		additional energy savings 1.5% annually	additional real final energy savings of 0.8% annually	binding
Interconnection in EU Member States	2017 in Germany: 9%	10%	15%[4]	indicative
Electricity trading/exchange		Make overall system more efficient and increase security of supply		

Source: Federal Ministry for Economic Affairs and Energy, 2/2018

1 See Chapter 3.2 in the full version of the Monitoring Report

2 Preliminary targets; Status in all of the EU: 09/2017; Status in Germany: 01/2018; whereby the 2005 baseline year emissions according to the EEA are calculated as follows: 2005 baseline year emissions = absolute 2020 target/(1 + % of the 2020 target)

3 compared with the trend in the reference figures for 2020 or 2030 (according to the PRIMES 2007 Model for the European Commission)

4 Additional thresholds make this figure more specific

Central measures of international energy policy

- Regulation on Governance of the Energy Union
- Amendment of the EU Renewable Energy Directive
- Amendment of the Energy Efficiency Directive
- Amendment of the Building Efficiency Directive
- Initiative on "Speeding-up the Conversion of Buildings to Clean Energy"
- revising the EU energy label
- Risk provisioning regulation
- Amendment of the Gas Supply Security Regulation
- cross-border grid expansion
- Commission Communication on Protecting Europe's Critical Energy and Transport Infrastructure
- Commission Communication on an interconnectivity target for 2030
- regional partnerships
- Revised Cross-Border Renewable Energy Ordinance (GEEV)
- Energy congestion management on the Austria-German border
- Regulation on the internal electricity market in the EU
- Directive on the internal electricity market in the EU
- ACER Regulation
- Regulation on determining a guideline for system equilibration in the electricity system
- Amendment of the Directive on the Internal Market for Natural Gas
- Tallinn e-Energy Declaration
- Energy Diplomacy Action Plan

European Commission by the end of 2018, and to submit the final plan for the years 2021-2030 by the end of 2019. These drafts will set out their national energy and climate targets along with strategies and measures they are planning to adopt in order to reach these targets. The Governance Regulation contains what are called "gap-filler mechanisms" that ensure that all Member States reach their targets. In the NECPs all five dimensions of the Energy Union are included (decarbonisation, energy efficiency, the European internal energy market, supply security and research, innovation and competitiveness). An essential aspect of these plans is that they require Member States to adhere to a specific structure so that they can be compared. The plans must be coordinated at the national level with stakeholders, and regionally with neighbouring countries. The Federal Government is currently developing a draft of its National Energy and Climate Plan.

3.2 Climate change mitigation in European emissions trading and outside of this area

Introduced in 2005, the European Union Greenhouse Gas Emission Trading Scheme (ETS) comprises emissions of around 12,000 plants and installations of the energy sector and energy-intensive industry, as well as emissions from intra-European aviation in the 28 Member States of the EU and Norway, Iceland and Liechtenstein. Together, these sectors account for roughly 45% of all emissions in Europe. The goal of reducing EU greenhouse gas emissions by 20% compared to 1990 levels has two parts: about two-thirds of the reduction should come from sectors within the ETS, and one-third from sectors outside of the ETS. This equates to a goal of 21% reduction by 2020 compared with 2005 for ETS sectors. To reach this goal, the total amount of emissions allowances available during the third trading period 2013–2020 must go down each year by 1.74%. The allowances will be either given to the installations or aviation operators for free, or they must buy them in an auction; they will be freely negotiable on the market.

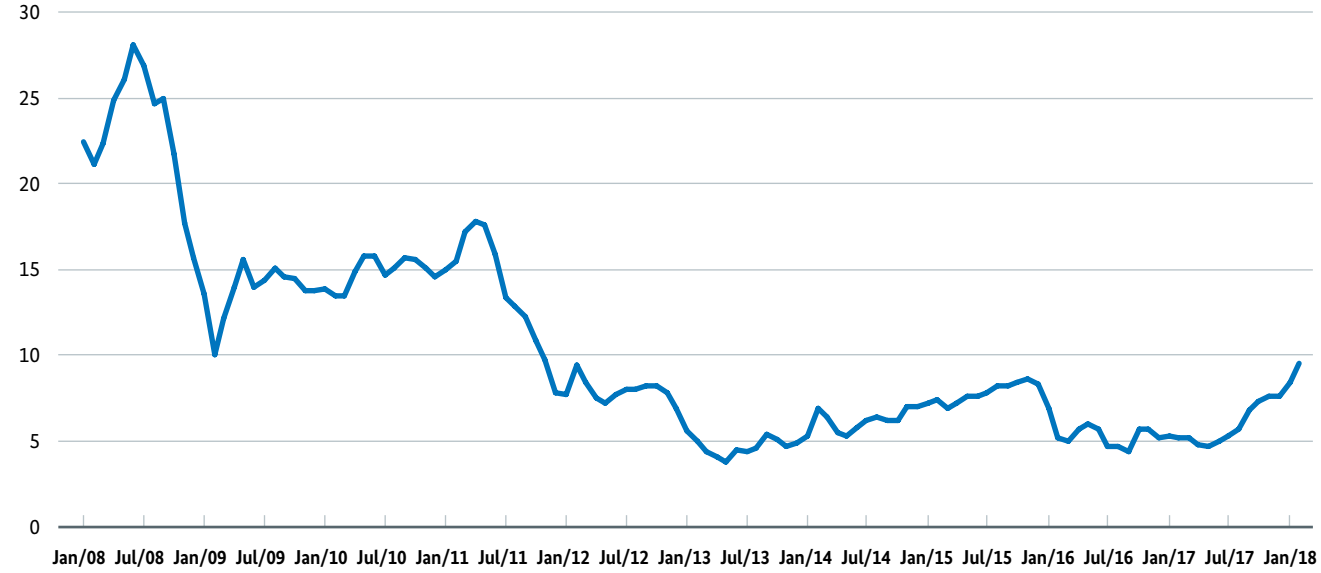
The reduction target for ETS areas was once again fulfilled ahead of schedule. In 2016 ETS sectors (not including European air transport) lowered their emissions by 2.9% over the previous year, leading to a 26% overall drop in emissions since 2005 – from 2,375 million tonnes to a total of 1,750 million tonnes of CO_2 equivalent. European air transport on the other hand recorded 7.6% increased emissions between 2015 and 2016. Nevertheless, according to analysis of preliminary data for 2017, ETS sector emissions are apparently slightly above the previous year's level (+ 0.3%) for the first time since 2010. This includes an increase in European air transport emissions of 4.98%, for stationary elements, 0.25% compared with 2016.

According to information provided by the German Emissions Trading Authority (DEHSt), in 2016 approximately 1,860 installations were included in the ETS (without air transport), of which about one-half comprised energy and industry sector facilities. Taken together, they emitted 453 million tonnes of CO_2 equivalent – 0.6% less than the previous year. This meant that the reduction was significantly lower than the European average amount. The reduction was attributable solely to the energy sector, while industry sector emissions remained constant, due to the strong economy. Emissions of the ETS in Germany went down by 13% overall between 2005 and 2016. Preliminary numbers for 2017 show that German emissions within the ETS went down by another 3.4%; in contrast to overall EU emissions, the reduction in the energy sector more than counteracted an increase in industry emissions.

An effective emissions trading system requires adequate price signals for investments. In past years, however, the allowance price has followed a strong downward trend (see Diagram 3.3). The reason for this decline was that large amounts of excess certificates mounted up – at the end of 2016, the total excess was 1.6 billion certificates, and at the end of 2017, 1.65 billion certificates. When the European emissions trading reform for the fourth trading period entered into force on 8 April 2018, the German Federal Government joined with other Member States in strengthening emissions trading in the long term, and in particular, its price signals. Measures taken to strengthen emissions trading will help to rapidly and permanently reduce the current certificate surplus. This can be expected to bolster the price as the supply of certificates goes down. After negotiations on reforming the ETS were concluded in 2017, the price for emission allowances has approximately doubled to around €15 per tonne of CO_2 (as of June 2018).

Reducing the surplus should strengthen the ETS. To this end, a market stability reserve will be activated as of 2019. The supply of allowances in the emissions trading market will be adjusted on the basis of an annual surplus analysis by moving parts of the surplus into the reserve, removing them from auctions. If the surplus falls below a predetermined minimum amount, allowances will be moved out of the reserve and back to the market. The market stability reserve should also bolster the so-called backloading effect, which resulted in retention of 900 million allowances between 2014 and 2016 that should have been auctioned in the

Diagram 3.3: Carbon allowance prices in the EU emissions trading system
€/t CO_2



Source: European Energy Exchange, 02/2018

period 2019–2020. These allowances will now be deposited directly to the market stability reserve. The 2018 ETS reform provided for an increase in the percentage of allowances taken out of the market stability reserve, from 12% to 24% of the amount in circulation, which would result in a reduction of the ETS allowances by about 2021. In addition, as of 2023, the amount of allowances held in the market stability reserve will be limited to the amount auctioned in the previous year; the remaining allowances will be deleted from the reserves. In total, it is likely that about 2 billion allowances will be deleted in the fourth trading period.

Even after 2020, the ETS will remain the most important tool for cutting greenhouse gases in the EU. The reform of the ETS will pave the way. To reduce emissions by 40% by 2030 as compared with 1990 levels, the ETS sectors must reduce their emissions by 43% using 2005 as the base year. This means that the overall number of allowances will decline more quickly – starting in 2021, by 2.2% annually instead of the 1.74% in the current trading period. This is equivalent to a reduction of about 484 million tonnes of CO_2 equivalent between 2021 and 2030 – which is more than half of the total annual greenhouse gas emissions in Germany. Non-EU countries will no longer have the option of emission reduction using the Clean Development Mechanism (CDM) or Joint Implementation (JI) after 2020.

Additionally, the reform ensures that industry – energy-intensive and exposed to internationally competition – will continue to be cushioned from unfair competition from companies in countries with lower environmental standards. Accordingly, the next trading period will also contain provisions to curb carbon leakage (Chapter 10), which refers to the practice of transferring CO_2-emitting production to countries with less stringent climate change policy, which may lead to an increase of global emissions of all types. To avoid this, the next trading period will continue to observe regulations on allocating a reasonable number of free allowances to polluters that are at risk of transferring their emissions. However, compared with the current trading period, the regulations focus more specifically on the carbon leakage risk. The list of sectors subject to carbon leakage risk is now compiled on the basis of a combination of trade and emission intensities. Furthermore, an innovation fund will be set up to sponsor technologies that should contribute in the long term to transforming the economy to make it more climate friendly. Innovate industry technologies in Germany will also be eligible for funding. The coalition agreement between the CDU, CSU and SPD contains provisions to strengthen the EU ETS as a major tool.

Other areas in the world have also created an emissions trading scheme or are about to do so. This includes China, California, New Zealand and Switzerland. The EU has signed a convention with Switzerland that aims to integrate both systems. The coalition agreement also aims for a global CO_2 pricing system, or at least for the G20 countries.

However, simply pointing to the success of an emissions trading system is not enough to achieve the EU emission reduction target – even the non-ETS sectors (especially buildings, non-aviation transport, agriculture and waste) make a decisive contribution. In 2016, emissions from these sectors was already 13% lower than 2005, yet the trend in the past few years has indicated a rise, due to low oil prices and weather-related heating needs. However, it is expected that the EU will reach its goal of a decrease of 10% in non-ETS sectors by 2020.

Central measures in the area of climate change mitigation in European emissions trading and outside of this area

- Market stability reserve in the EU emissions trading system
- reform of the emissions trading system for the period 2021–2030
- moving allowances that were held back into the market stability reserve
- linking the EU emissions trading system with the Swiss emissions trading system
- Effort Sharing Regulation
- Strategy for low-emission mobility
- 'Europe on the Move' mobility package
- Second mobility package for regulating CO_2 emissions of passenger cars and light commercial vehicles

Whereas the target for the ETS sectors is not allocated to Member States, the reduction target for non-ETS sectors is divided into national targets for each individual Member State. These targets were adopted in the 2013 ESD Effort Sharing Decision. Even though the majority of the Member States will probably fulfil their obligations, Germany may miss its target of a 14% reduction in the non-ETS area by 2020. Member States are not however legally bound to fulfilling their 2020 targets as of a strict and precise date. Instead, they must only furnish proof that they have enough emissions allowances for each year from 2013 to 2020 from the Effort Sharing Decision to actually cover their emissions. Unused allowances may be transferred without restriction to later years of the allocation period or transferred to other Member States. If the amount of emissions credits saved between 2013 and 2015 that are below the individual annual assignment is not sufficient for balancing out any deficits by 2020, carbon allowances may be purchased from EU countries that exceeded their targets.

The new Efforts Sharing Regulation will become effective in the summer of 2018. It stipulates that by 2030, greenhouse emissions across the EU should be reduced by at least 30% compared with 2005. Binding national targets for this period range between 0% and 40% cuts in greenhouse gas emissions – Germany is in the upper range at 38%. The target level corresponds to national sector targets for 2030 under the 2050 Climate Action Plan, and has risen substantially compared with the 2020 target. In the period between 2020 and 2030 annual reductions will be need to be substantially greater than up until now. To a certain extent, Member States may spread their allotted annual allowances over a time period or transfer them amongst themselves.

In order to curb emissions in the transport sector, the European Commission devised a strategy for low-emission mobility in July of 2016. The strategy defines planned initiatives in three distinct areas: a more efficient transportation system, use of low-polluting sources of energy in the transport sector as well as low-emission or non-polluting vehicles. In May 2017 the EU Commission outlined the mobility package 'Europe on the Move', a long-term plan for clean and competitive mobility, and instigated several specific initiatives. These include the functionality of the road haulage market as well as a smart road pricing scheme.

The second mobility package that followed in November 2017 contains nine draft laws that also address regulation of carbon emissions for passenger cars and small commercial vehicles for the period after 2021. The new car fleets are required to emit 15% less carbon in the period to 2025 compared with 2021, and 30% less by 2030. Any violation of these regulations will be punished with a fine. On the other hand, the package does not provide for a binding minimum percentage of electric cars. Instead, the EU Commission intends to use an incentive system to reach its target for 2030 of 30% new cars powered by electric motors or alternative powertrains (Chapter 7).

3.3 International energy policy

In 2015 and 2016, the increase in global energy-related CO_2 emissions came to a stop (see Diagram 3.4). This is attributable to the decline in use of coal in many regions, progress toward energy efficiency and the growing share of renewables in energy production. However, in 2017, carbon emissions increased again by 1.4%, according to the IEA.

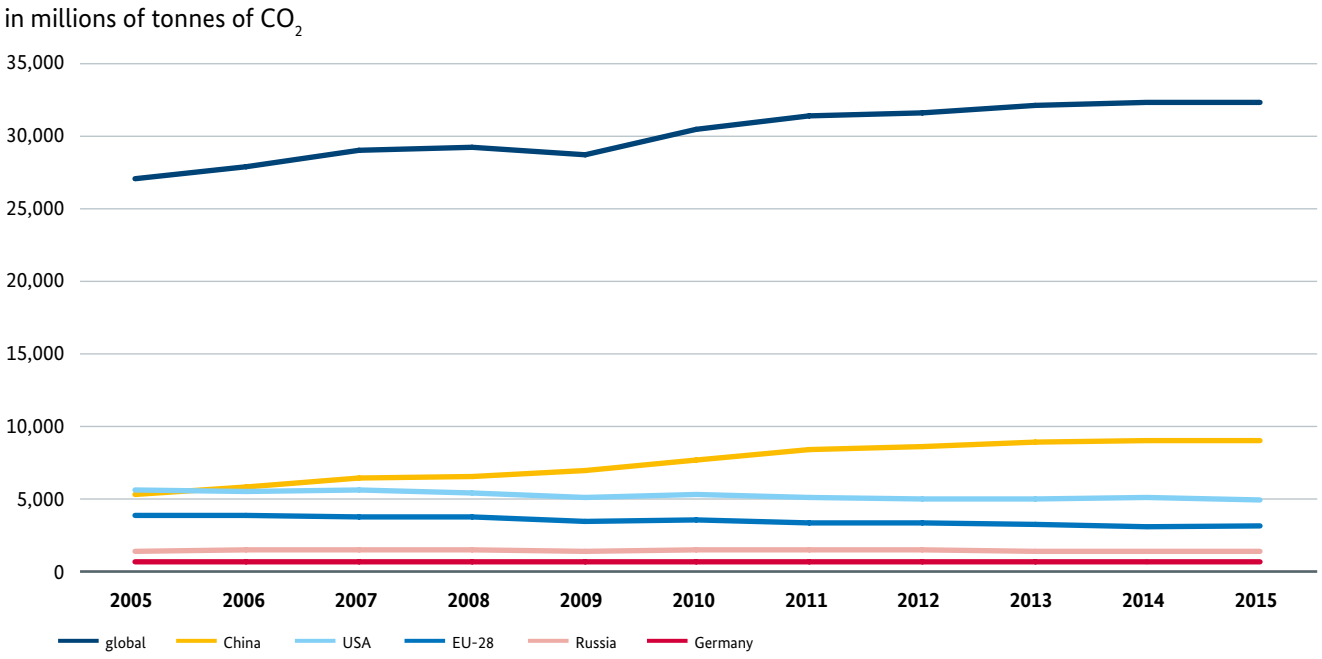
The biggest polluter is China, with over more than one-fourth of total global emissions. Understandably, this country has a big influence on global emissions trends. The slower rise in past years is basically due to the fact that emissions in China hardly went up at all. In December 2017 China initiated its own market for carbon allowances, which has now taken over the role of the European ETS as the largest market in the world. The Chinese market currently only includes the energy sector – the 1,700 power plants currently involved produce about one-third of all Chinese emissions, according to the China Carbon Forum.

One example of an international initiative for reducing pollution outside of the emissions trading scheme comes from the shipping industry: 173 member states of the International Maritime Organisation recently agreed to voluntarily reduce carbon emissions of their ocean-going merchant fleet by more than one-half of 2008 levels. Maritime traffic is certainly a significant contributor to pollution, responsible for 2% to 3% of global CO_2 emissions. It emits more carbon dioxide each year than all of Germany.

The global energy transition is making progress across the board toward lower-emission energy supplies. According to the IEA, around 40% of USD 718 billion in total investments in the electricity supply sector went to renewable energy sources and expansion of electric grids, and only slightly more than 16% went to fossil energy generation. Over 2,000 gigawatts were produced with renewable energy at the end of 2016, and at the end of 2017, over 2,100 gigawatts of capacity were available, an annual increase of 8% for both periods. Among declining costs and technological advances, photovoltaics capacity expanded much more rapidly than all other types of energy generation – a first.

In past years, the costs of photovoltaic and wind technology in particular have gone down significantly, which encourages strong growth in renewable energy generation, especially in developing and newly industrialised economies. In 2016, over half of new capacity was created in non-OECD countries. China, with the most investment, was involved in almost one-third of all investments, and Europe could claim almost 20% of investment volume. The total investment volume in renewable energy provides a similar picture: here, too, China contributed about one-third in 2016, and in 2017, even 45%, according to the Frankfurt School UNEP Collaborating Centre for Climate & Sustainable Energy Finance/BNEF. Given this, China – not Europe – has been the region with the largest investment volume since 2013, and its lead is growing rapidly. However, if we look at the rate at which the power plant park is being transformed, EU countries are at the forefront globally. In 2016, approximately 86% of all new power plants in this region were based on renewable energy sources, compared with only 62% worldwide.

Diagram 3.4: Energy-related CO_2 emissions in selected areas of the globe



Source: International Energy Agency, 09/2017

With regard to installed power, Germany was the European leader in 2016, with more than 100 gigawatts, which was about one-fifth of European installed power. Worldwide only China, the USA and Brazil had more capacity for power generation from renewable energy sources (see Diagram 3.5). The situation was similar in 2017.

In 2015, renewables provided more than one-eighth of global primary energy consumption, and almost one-fifth of final energy consumption. Modern renewable energy sources and traditional biomass were equal contributors, whereas modern renewables were gaining in importance. All renewables together provided almost one-fourth of electricity generation.

Energy efficiency continued to improve at an international level. In 2016, the energy intensity dropped by 1.8% over the previous year. In the years before that, there were even larger drops: between 2010 and 2015, the average rate was 2.1% annually. Investments in energy efficiency amounted to USD 231 billion in 2016, which was an increase of over 9% over the previous year. China is a driving force in this trend, even if the largest proportion of energy efficiency investments is still spent in Europe. According to IEA studies, the rise in energy efficiency is currently the most important counter-influence for the increase in carbon emissions (OECD/IEA 2017a).

The Paris Convention on Climate Change that entered into force in November 2016 provides the overall framework for the global energy transition. The Convention has three main goals:

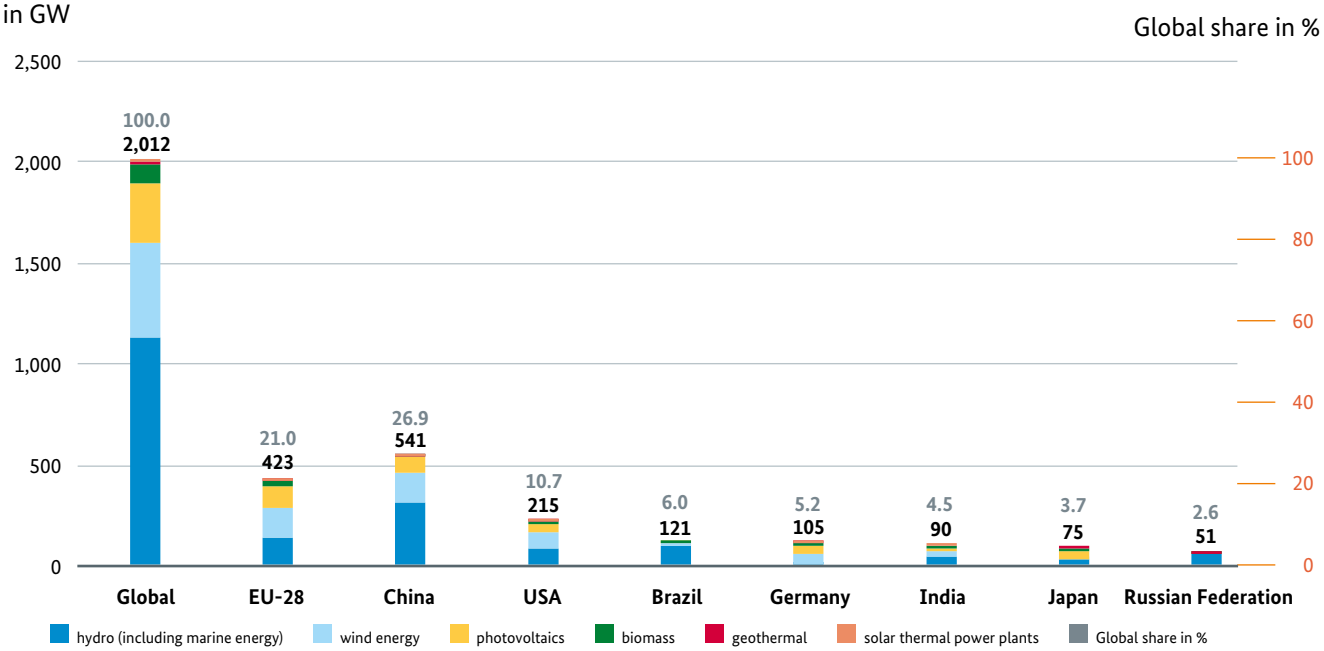
- reducing global warming to well below 2° compared with the pre-industrial era;
- becoming able to adapt to climate change;
- aligning global financial flows with climate change goals.

The convention has been signed by 178 of the 197 countries, including the EU and Germany. The convention requires all contracting states to make national climate protection contributions (NDCs: Nationally Determined Contributions). The Federal Government has several programs to ensure rapid implementation of NDCs worldwide. In June 2017, US president Donald Trump announced that the USA would withdraw from the Convention; however, this would become effective in November 2020 at the earliest. The long-term effects of this are difficult to forecast – many US states and cities still pursue strong climate protection policies. As it turns out, no other countries have followed the US example.

Germany is an important partner for many countries in organising the international energy transition. There is strong interest all over the globe in German expertise and technology, for example in adapting the legal framework or integrating renewables into a secure supply system. The fact that there is successful exchange of ideas, for example the annual Berlin Energy Transition Dialogue, illustrates how swiftly energy systems are being transformed in many regions of the world. This is good news, because the global energy transition opens up opportunities to reduce costs and use synergies. Another example is the initiative started by Germany, Norway and the United Arab Emirates to found a Global Commission on the Geopolitics of Energy Transformation under the auspices of IRENA. This is an international expert committee that deals with geopolitical effects of the global energy transition.

The coalition agreement between the CDU, CSU and the SPD plans to expand international cooperation on energy, by utilizing existing organisations such as the G20 or G7 or international energy institutions (IEA, IRENA) and developing other bilateral energy partnerships. The goal is to create a worldwide network for the German economy, create new market potential and promote the global energy transition.

Diagram 3.5: Global installed renewable capacity, 2016



Source: 2017 REN21

At the G20 summit held in July 2017 in Hamburg under German presidency the heads of state and government – without the USA – resolved a G20 Action Plan on Climate and Energy for Growth. In this plan the countries express their commitment to unrestricted implementation of the Paris Agreement and the goals of the Agenda 2030 on sustainable development, as well as efficient transformation of energy systems. This is an important signal, because the G20 countries are responsible for about 80% of global primary energy consumption, and even more than 80% of all CO_2 emissions.

A study conducted by IEA and IRENA during the German G20 presidency on the prospects for the energy transition show that extensive decarbonisation of the energy system by 2050 is ambitious, yet technically possible and economically feasible (OECD/IEA and IRENA 2017). The additional investment required for this in the period up to 2050 would be equivalent to about 0.3% of global GDP. Investments in energy efficiency of all sectors would have to increase by a factor of 10 compared with the current level. Investments in energy generation would not increase significantly, but much of the funding would have to be diverted, especially to renewables.

Central measures in international energy policy

- G20 Action Plan on Climate and Energy for Growth
- 23rd World Climate Conference (COP 23)
- IEA/IRENA Study: Perspectives for the Energy Transition – Investment Needs for a Low-Carbon Energy System carried out under the auspices of the German G20 presidency
- deepening existing bilateral energy partnerships and creating new ones (recently with Mexico, United Arab Emirates and Australia)
- Berlin Energy Transition Dialogue
- Energy Export Initiative
- Travelling exhibition: Energiewende – Germany's Energy Transition

Part I: QUANTITATIVE TARGETS OF THE ENERGY TRANSITION

The quantitative targets of the energy transition refer to five thematic areas

Renewable energy

Energy consumption and energy efficiency

Buildings

Transport

Greenhouse gas emissions

4 Renewable energy

Where do we stand?

With a share of 31.6% in gross electricity consumption, almost one kilowatt hour of electricity in three was derived from renewable sources in 2016. There was a strong increase of this ratio in 2017.

The share of renewables in final energy consumption increased slightly compared with the year before, by 13.2%. In the transport sector the contribution of renewable energy to final energy consumption was 5.2% – a slight decline from the previous year, which was 5.3%.

What is new?

The EEG 2014/2017 introduced competitive auctions for solar, wind energy and biomass power plants. The tenders bring about cost efficiency in funding for ground-mounted solar PV systems as well as for wind power plants both on land and offshore.

The Landlord-to-Tenant Electricity Act allows tenants to profit directly from the energy transition and creates new incentives for expanding solar energy generation in Germany.

The Coalition Agreement between the CDU, CSU and SPD provides for additional expansion of renewable energy that is effective, efficient, synchronized with energy grids and increasingly competitive. With these requirements in place, the goal is a 65%-share of renewables by 2030; any corresponding adjustments will be made. Special auctions for wind and solar energy aim to help reach the 2020 climate protection goal. The challenge is to better synchronise renewables and grid capacity expansion.

	2016	2020	2030	2040	2050
Renewable energy					
Share of gross final energy consumption	14.8%	18%	30%	45%	60%
Share of gross electricity consumption	31.6%	at least 35%	at least 50% Renewable Energy Sources Act 2017: 40–45% by 2025*	at least 65% Renewable Energy Sources Act 2017: 55–60% by 2035	at least 80%
Share of heat consumption	13.2%	14%			

* The Coalition Agreement between the CDU, CSU and SPD provides for additional expansion of renewable energy that is effective, efficient, synchronized with energy grids and increasingly competitive. With these requirements in place, the goal is a 65%-share of renewables by 2030; any corresponding adjustments will be made. Special auctions for wind and solar energy aim to help reach the 2020 climate protection goal. The challenge is to better synchronise renewables and grid capacity expansion.

4.1 Share of renewables in gross final consumption of energy

The share of renewables in total energy consumption is rising across the board. Gross final energy consumption comprises the final energy delivered to final consumers before deduction of losses incurred in conversion and transmission in the three sectors of electricity, heating and transport (fuels). Electricity covers around one quarter of our total demand for energy, while process heating and space heating cover around one half, and fuels cover roughly one quarter. In 2016, the gross final energy provided by renewable sources amounted to 385.6 TWh, thereby covering 14.8% of total gross final energy consumption. This represents a slight increase over the previous year of 0.1 percentage points. (See Diagram 4.1).

The share of renewables in gross final electricity consumption has risen by more than half (5.6 percentage points) since 2008. Overall, the share of renewables across all three sectors has even trebled since 2000. This positive development has primarily been driven by the increase in renewable generation in the electricity sector. The share of renewables in the heating sector went up slightly, and the share of renewables in the transport sector has been slowly declining since 2008. A difference of 3.2 percentage points must be closed to reach the 18% target by 2020. This target can only be achieved by continuing the ambitious expansion of renewables in the electricity and heating sectors, and by stepping up efforts significantly in the transport sector.

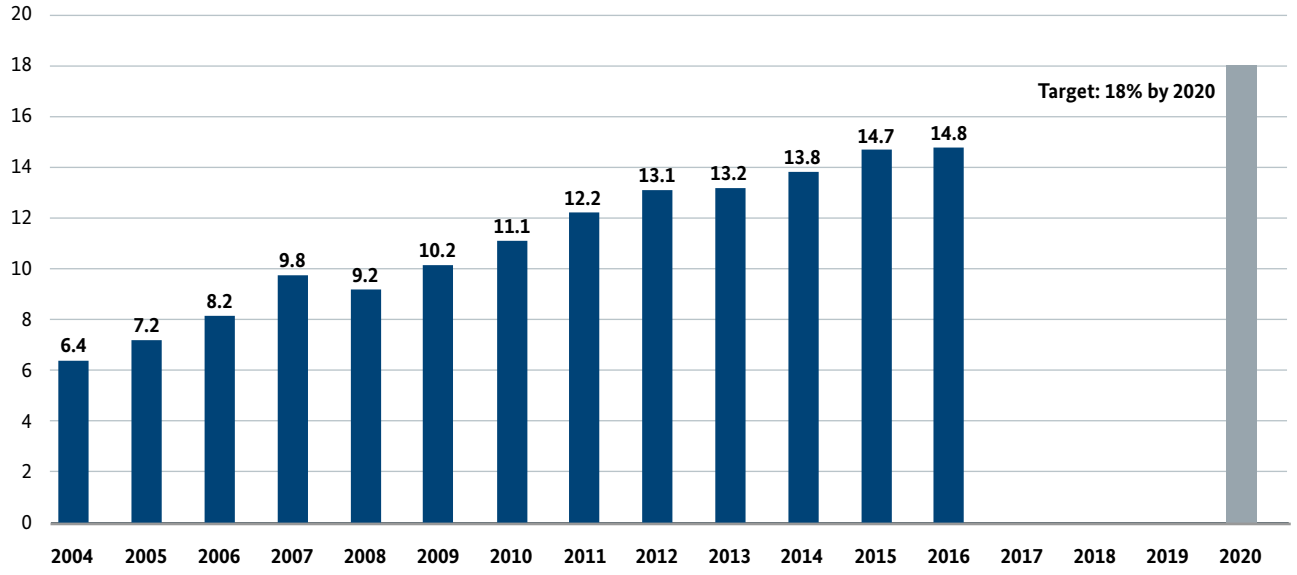
The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of increasing to 18% the share of renewable energy sources in gross final consumption of energy by 2020 will be reached. One major factor is the high proportion of renewables in the electricity and heating sectors. The study assumes that this percentage will be at 18.4% by 2020 (within a range of 17.7% to 20.0%, see Diagram 4.2). This takes the effects of measures taken under the Study into account.

Additional steps in implementing the energy transition build increasingly on the integrated development of the electricity, heating and transport sectors. The importance of renewables can be expected to increase in all three sectors over the coming years also. In addition to increased energy efficiency and the expansion of renewables, there will also be greater interaction between the energy, transport and buildings sectors (sector coupling) in the future (see Chapter 13.1).

Diagram 4.1: Meeting the target for renewable energy and gross final energy consumption

2020 target	Renewables will cover 18% of gross final energy consumption
Status in 2016	14.8%

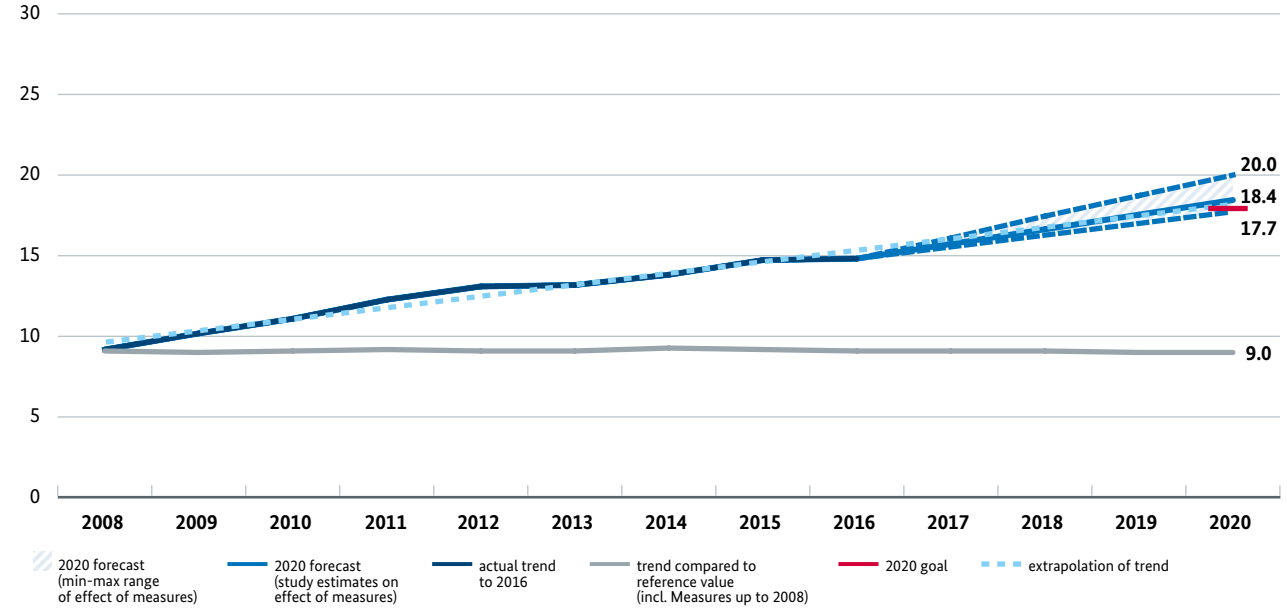
Percentage of gross final energy consumption



Source: AGEE-Stat 02/2018

Trend	●●●●●
Measures	Renewable Energy Sources Act, Market Incentive Programme, Renewable Energies Heat Act, greenhouse gas quota, amongst other measures

Diagram 4.2: Increase in the share of renewables in final energy consumption according to the Target Architecture Study
in %



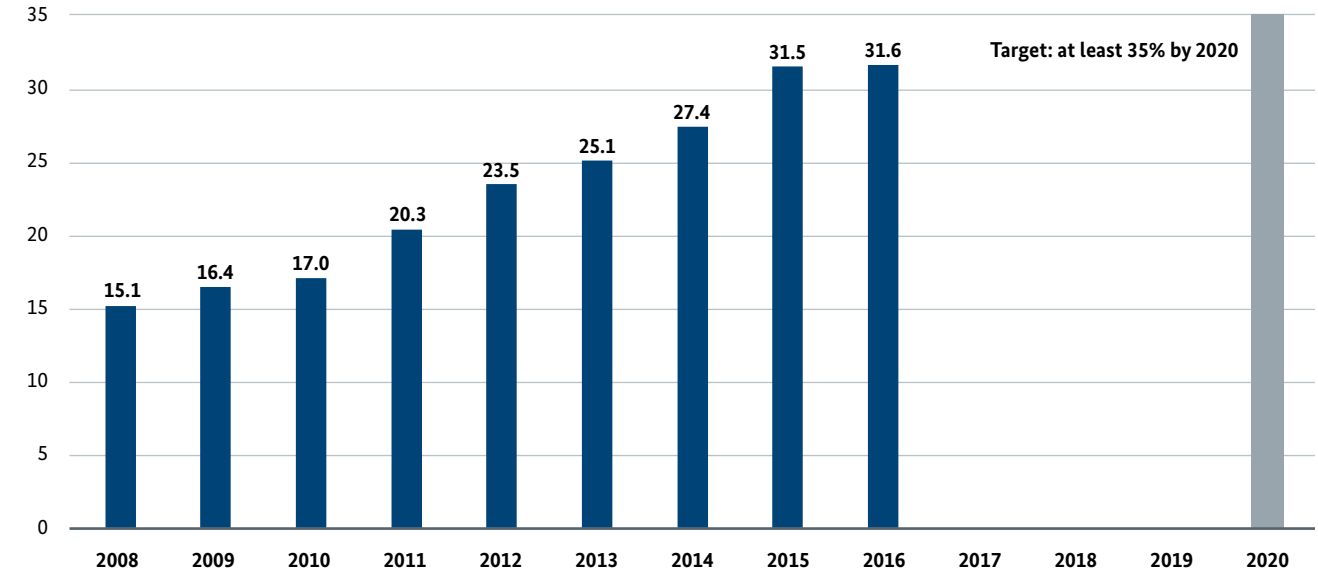
Source: Prognos, Fraunhofer ISI, DLR (2018)

4.2 Renewable Energies in the electricity sector

At 189.7 TWh, electricity generated from renewable sources in 2016 was only slightly over the previous year (2015: 188.8 TWh). Despite a sizeable increase in installed capacity, weather factors stymied a corresponding increase in electricity generated with renewables, which was 31.6% of gross electricity consumption (2015: 31.5%) (see Diagram 4.3). The share of renewable energy in the electricity sector has

Diagram 4.3:	**Meeting the target for renewable energy and gross final energy consumption**
2020 target	Renewable energy to provide at least 35% of gross electricity consumption
Status in 2016	31.6%

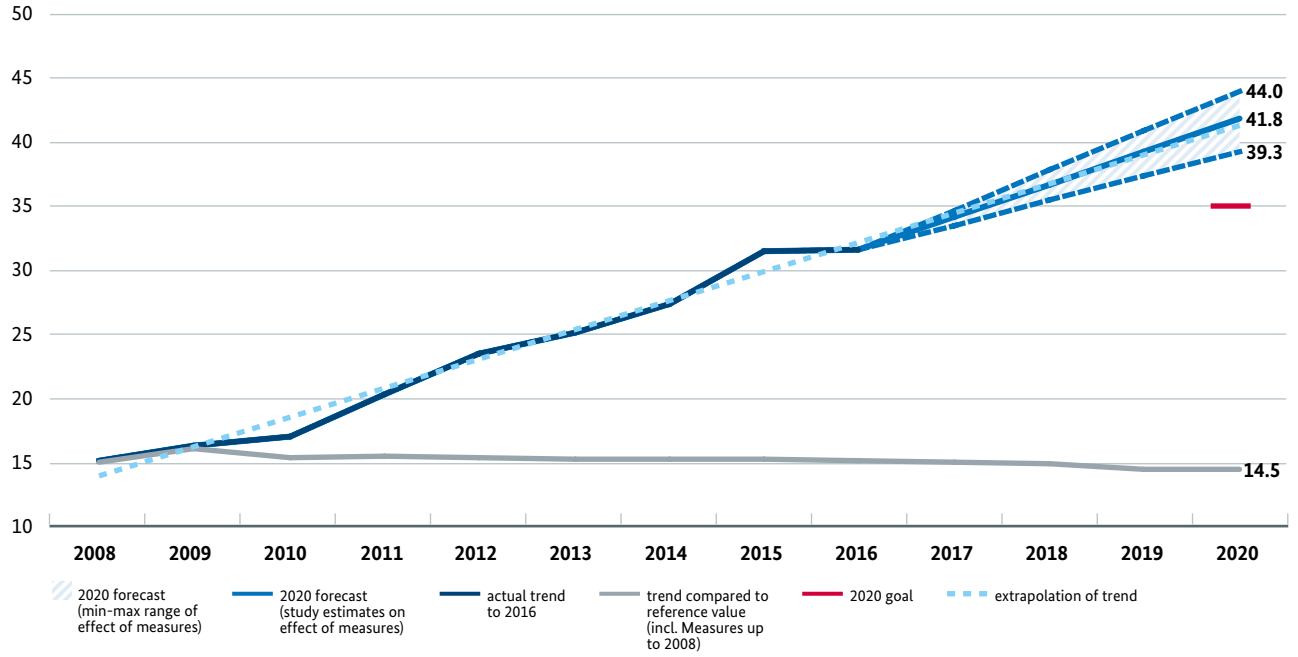
Percentage of gross electricity consumption



Source: AGEE-Stat 02/2018

Trend	● ● ● ● ●
Measures	Renewable Energy Sources Act

Diagram 4.4: Increase in the share of renewables in gross electricity consumption according to the Target Architecture Study
in %



Source: Prognos, Fraunhofer ISI, DLR (2018)

more than doubled since 2008. The Federal Government has achieved a great deal in its efforts to provide a secure, affordable and environmentally-friendly energy supply system. The share of renewables in gross final energy consumption in 2017 grew to 36.2% – the strongest rise within one year – thereby already exceeding the 2020 goal (35%) in 2017.

The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of increasing to at least 35% the share of renewable energy sources in gross electricity consumption by 2020 will be reached. The study assumes that this percentage will be at 41.8% by the year 2020 (within a range of 39.3% to 44.0%, see Diagram 4.4). This takes the effects of measures taken under the Target Architecture Study into account.

Onshore wind energy capacity was substantially expanded again in 2016. However, this expansion didn't immediately affect wind power generation because there was relatively little wind in 2016. Despite a 4.2 gigawatt (net) increase in capacity, power generation from onshore wind-powered installations dropped more than 6% in 2016, to 67.7 TWh from 72.3 TWh in 2015. Offshore wind powered electricity supply gained in importance, with an increase from 8.3 TWh in 2015 to 12.3 TWh in 2016. In total, wind energy provided around 80 TWh in 2016, 13.3% of the total German gross electricity consumption, only slightly below the previous year (2015: 13.5%).

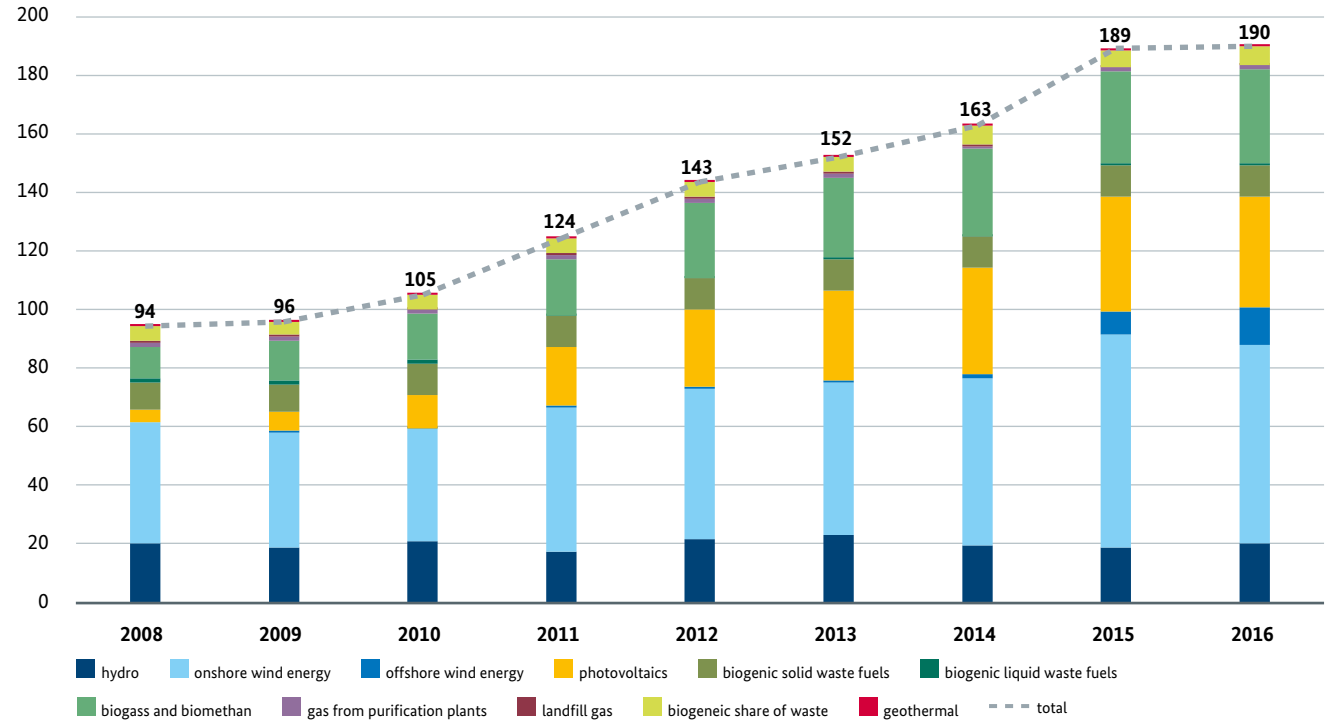
Power from photovoltaics (PV), biomass and geothermal energy remained constant in 2016. Due to the reduced total sunshine in 2016, power generation from PV was slightly below the previous year at 38.1 TWh (2015: 38.7 TWh), despite the increase in capacity of 1.492 MW (2015: 1,324 MW). Approximately 50.9 TWh of electricity was generated from solid, liquid and gas biomass, including waste deposit and sewage gas as well as biogenic portions of municipal waste (2015: 50.3 TWh). Biomass contributed 8.5% of total gross electricity consumption in 2016. At 20.5 TWh, hydroelectricity exceeded the previous year of production (2015: 19 TWh) due to greater precipitation. This corresponds to around 3.4% of gross electricity consumption. Geothermal power for electricity generation remained insignificant, yet increased slightly, at 175 GWh (2015: 133 GWh).

From a long-term perspective, the construction of additional wind and photovoltaic capacity, in particular, is expected to continue to drive the expansion of renewables. As Diagram 4.5 illustrates, electricity generation from renewables has doubled in since 2008, rising from 94 to 189.7 TWh. The major driver was PV, and in recent years, expansion of use of offshore and onshore wind energy. On the other hand, the strong growth in the past in biomass has recently slowed. The shares of hydropower and deep geothermal energy have remained virtually unchanged.

Renewable energy resources expansion is progressing well in the area of wind energy, but is slower in the other technologies. The expansion of onshore wind is central to the success of the energy transition in the electricity sector, with 4,436 MW (gross) of new capacity installed in 2016. With decommissioned plant capacity factored in, total net onshore capacity added amounted to 4,157 MW. The expansion is therefore roughly 1,700 MW above the deployment corridor of 2,500 MW defined in the Renewable Energy Sources Act of 2014. At the same time, additional photovoltaic capacity in 2016 – standing at 1,492 MW of installed capacity – was just less than 1,000 MW short of the deployment corridor of 2,500 MW defined in the Renewable Energy Sources Act 2014. New offshore wind installations with a capacity of 849 MW were added. The slowdown in biomass (solid, liquid and biogas) continued, but at 32 MW (gross, without increased capacity with the goal of flexibility) biomass fulfilled the requirements of the deployment corridor (<100 MW).

On the whole, renewables are consolidating their strong position in the German electricity mix. Total gross electricity generation in Germany increased in 2016 (see Diagram 4.6). Compared with the previous year, the share of renewable energy sources in total electricity generation was nearly the same at 29.2% in 2016, due to weather effects (2015: 29.1%). This means that renewables produced roughly one third of German electricity in 2016 and were thereby able to retain their strong position in the electricity mix. As in previous years, onshore wind proves to be the most important renewable source of electricity with a share of approximately 10.4% (67.7 TWh) in total electricity generation.

Diagram 4.5: Gross electricity generation from renewable energy sources
in TWh



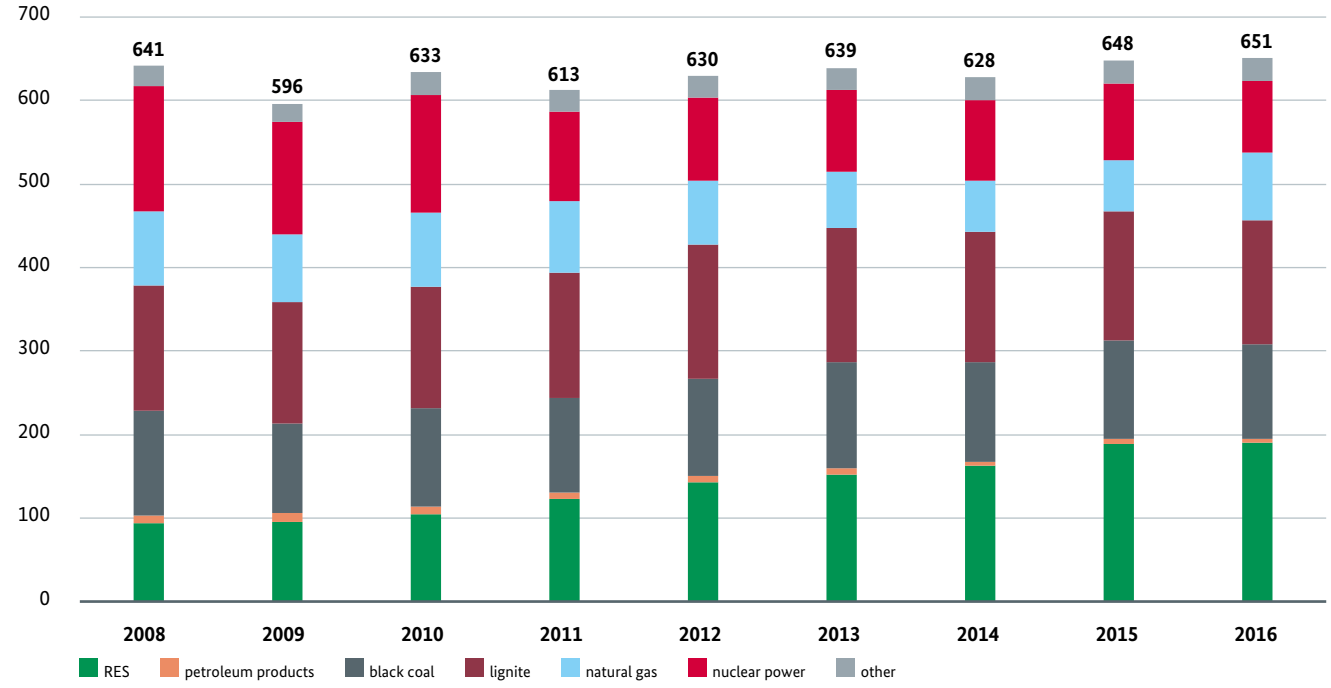
Source: AGEE-Stat 02/2018

Table 4.1: Deployment corridor as defined in the Renewable Energy Sources Act 2014 and actual new installations in 2016

Technology	Target to increase the installed capacity under Section 3 of the Renewable Energy Sources Act 2014	Actual new installations in 2016
Onshore wind	2,500 MW per year (net)	4,157 MW (net)
Offshore wind	6,500 MW by 2020; 15,000 MW by 2030	849 MW (4,132 MW cumulative net)
Photovoltaic	2,500 MW per year (gross)	1,492 MW (gross)
Biomass	up to 100 MW per year (gross)	32.4 MW (gross)*

Source: Working Group on Renewable Energy Statistics, 12/2017, Federal Environment Agency, Federal Network Agency. PV: gross = net
*The total increase in the installed capacity of biomass plants, primarily due to a non-generation-related change in capacity for flexibilisation purposes, amounted to 199 MW (net) in 2016.

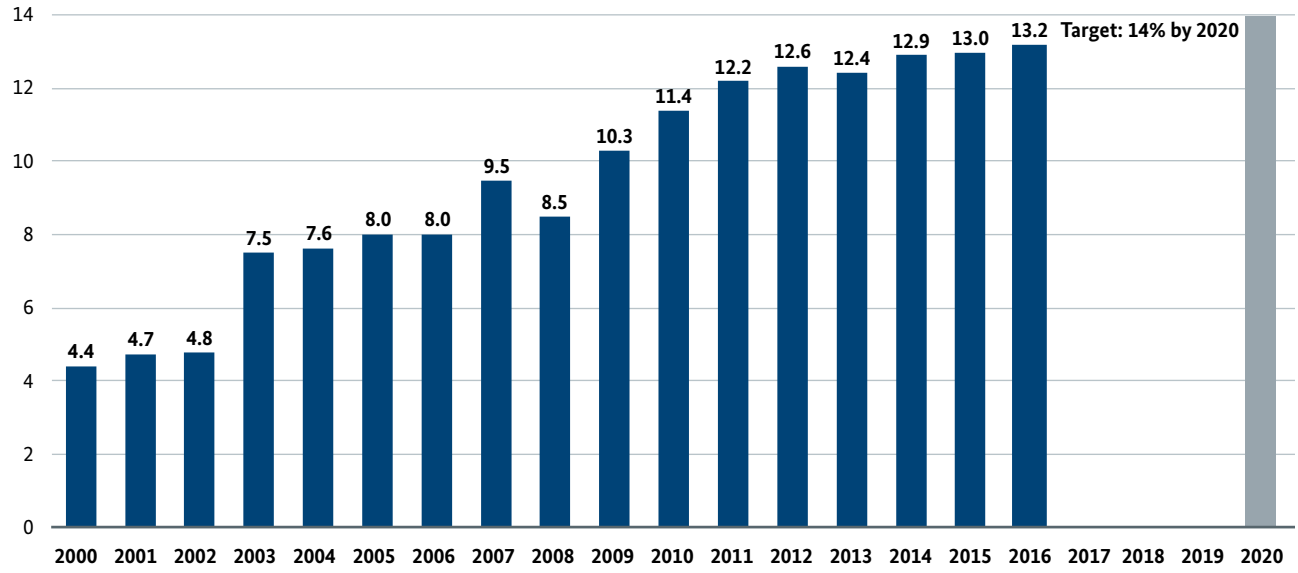
Diagram 4.6: Gross electricity generation by energy source
in TWh



Source: Working Group on Energy Balances, 02/2018

Diagram 4.7:	**Meeting the target for the share of renewables in heating and cooling energy consumption**
2020 target	Renewables to provide 14% of heating and cooling energy consumed
Status in 2016	13.2%

Share in heating consumption



Source: AGEE-Stat 02/2018

Trend	● ● ● ● ●
Measures	Renewable Energies Heat Act, Market Incentive Programme

4.3 Renewable energy in the heating sector

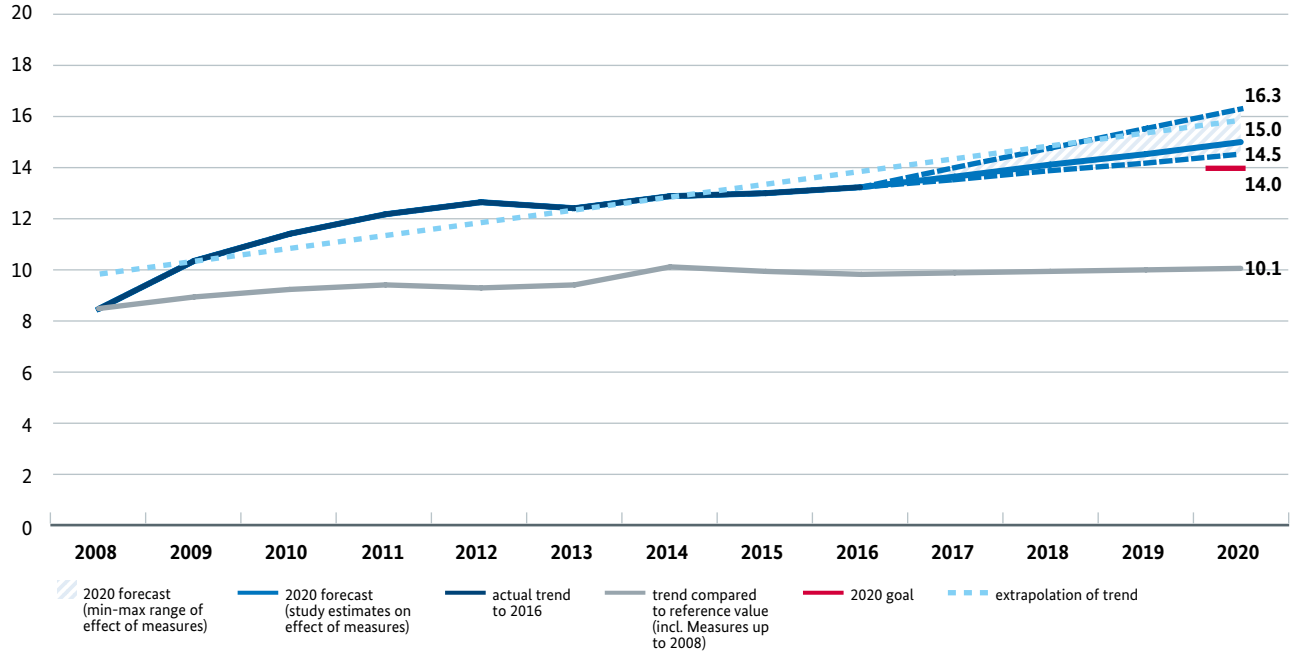
Usage of renewable energies for generating heat increased in 2016, due in part to relatively cool temperatures compared to the previous year. Total final energy consumption for heating and cooling went up by 3.3%, due to weather conditions. Accordingly, the share of renewables in total final energy consumption for heat and cooling was stable. In 2016, approximately 13.2% (about 163.7 TWh) of final energy consumption for heat and cooling was covered by renewable energy sources – in 2015 this figure was also 13%, at 155.5 TWh.

Biomass remains the leading renewable source of heat. In particular, wood consumption of private households (including wood pellets) rose last year, due to weather conditions. With a share of 87.6%, biomass (solid, liquid, biogas and biogenic waste) therefore remained the most important source of renewable energy in the heating sector overall. Heat pump heating systems and solar collectors provided 7.6% and 4.8%, respectively, of total heat derived from renewables.

The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of increasing to 14% the share of renewable energy sources in heating and cooling consumption by 2020 will be reached. The study assumes that this percentage will be at about 15% by 2020 (within a range of 14.5% to 16.3%, see Diagram 4.8). This takes the effects of measures taken under the Target Architecture Study into account.

Diagram 4.8: Increase in the share of renewables in heating and cooling consumption according to the Target Architecture Study

in %



Source: Prognos, Fraunhofer ISI, DLR (2018)

The share of renewables in the heating and cooling sectors must continue to increase steadily to deliver on the goal of the Renewable Energies Heat Act in 2020. The entire building stock in Germany is to be virtually climate-neutral by 2050. As the Energy Efficiency Strategy for Buildings has demonstrated, this will only be possible if serious progress is made by combining efficiency and the use of renewables for heating and cooling.

4.4 Renewable energy in the transport sector

The share of renewables in the total energy mix for the transport sector was down over the previous year, at 33.6 TWh or 5.2% (2015: 5.3%). The share of biofuels in total final energy consumption stood at 4.6% in 2016, and the renewable share of the electricity consumed by rail and road transport vehicles at 0.6%. Biofuels therefore account for almost 90% of renewable energy in the transport sector.

One cause for the downward trend in the share of renewables in the transport sector was the increase in the total final energy consumption in this sector. Accordingly, the total final energy consumption rose from 636 TWh in 2015 to 650 TWh in 2016 (without international air traffic), in particular due to the increase in passenger and freight traffic (see Chapter 7).

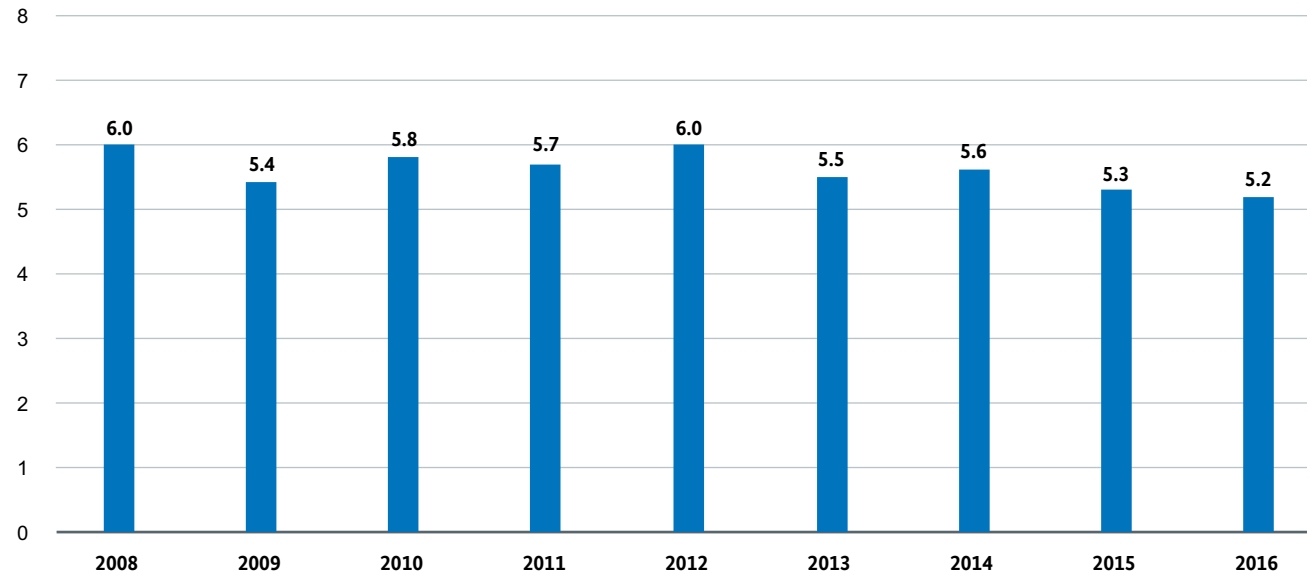
The greenhouse gas quota is currently being developed. The system of promotion was changed in 2015 from a quota based on energy content for biofuels to a greenhouse gas quota. Under the new regulations, the petroleum industry is required to reduce the greenhouse gas emissions per fuel unit by 3.5% from 2015, by 4% starting in 2017 and by 6% from 2020 onwards. In addition to biofuels, since January of 2018, other options for climate protection in transport may be applied to the greenhouse gas quota (e.g. electricity used in e-vehicles). Biofuels with low specific GHG emissions have entered the German market as a result of the GHG reduction quota (BLE 2016).

4.5 Renewable Energy Sources Act

The Renewable Energy Sources Act is the central instrument for steering the expansion of renewable energy. The Act has undergone continuous development since its introduction in 2000 – with amendments to the Act in 2004, 2009 and 2012, various photovoltaic revisions and the Renewable Energy Sources Act 2014 – as well as the most recent revision, the Renewable Energy Sources Act of 2017.

- The reform of the Renewable Energy Sources Act 2014 stipulated that the level of financial support for renewable energy was to be set by auction in a competitive framework by 2017 at the latest. To this end, the first pilot auctions for ground-mounted PV installations were held in 2015 and 2016. The aim was to build on the experience from these auctions to implement the system change. In addition, the Renewable Energy Sources Act 2014 also introduced the compulsory direct sale of electricity. Since then, anyone producing electricity must also sell it.

Diagram 4.9: Meeting the renewables target in the transport sector
Share of RES in transport



Source: AGEE-Stat 02/2018

- The Renewable Energy Sources Act 2017 created a paradigm shift in renewable energy funding towards more competition and greater cost efficiency. The most important renewable energy sources – onshore and offshore wind energy, large photovoltaic systems and biomass – are now required to compete in auctions, where only the cheapest offers are awarded contracts. This is the end of a phase of technology support with fixed funding rates – but hydropower, geothermal energy and small PV roof systems still have fixed feed-in tariffs.

Compared with total generation capacities, the share of generation capacities registered with grid operators for the market premium increased from around 43% in 2013 to over 58% in 2016 (2017: 60% on average). At the end of 2016, generation capacities in the system of direct marketing totalled around 59.2 GW. With around 45 GW, wind energy continues to dominate the portfolio of RES electricity sold directly. The registered capacity for PV stood at around 8.2 GW at the end of 2016, while that for biomass was roughly 5.1 GW. More than 90% of the installed capacity of onshore and 100% of offshore wind installations sell their electricity through the market premium system. The corresponding share for biomass is around 74% and around 20% for PV.

Some 118 TWh of renewable electricity were supported through the market premium system in 2016. This is equivalent to roughly 63% of all electricity produced from renewable sources and an increase of over 3% over the previous year. Total funding through the market premium system amounted to roughly €12.6 billion in 2016 (2015: €11.6 billion).

Initial results from the competitive auctions for expanding wind energy and PV under the EEG revisions in 2014 and 2017 confirm that these reforms are important steps on the path to a successful energy transition. The auctions have led to significantly lower support costs.

- Solar installations: PV auctions are geared to the experience gathered in 2015 and 2016 from pilot auctions for ground-mounted installations. Three auctions were conducted in 2017 in compliance with the EEG 2017. The trend that was evident already in the first pilot auctions has continued in the first auctions under the EEG 2017. The auctions evidenced a high level of competition and were often oversubscribed. The average funding rate for electricity from large PV installations continues to go down and saw a reduction of about 50% in all auction rounds (including the pilot phase). The lowest average award price in the February auction was 4.33 cents per kWh. More information can be found in Table 4.2. The final realisation rates for the four pilot auctions in 2015 and 2016 show that on average, 95% of the projects that were awarded government funding were initiated and went into operation within the two-year implementation period.

- Onshore wind energy: in May of 2017, the first auctions for onshore wind energy installations in accordance with the new rules of EEG 2017. In conjunction with the PV auctions, three auctions for onshore wind energy in 2017 were marked by a high competition level and declining funding rates. The average amount-weighted awarded price in the first round sank from 5.71 ct per kWh

Table 4.2: Results of the first auction for solar installations under the EEG 2017

Auctions in 2017				
Auction date	1 February 2017	1 June 2017	1 October 2017	1 February 2018
Number of offers received	97	133	110	79
Volume offered	488 MW	646 MW	754 MW	546 MW
Excluded offers	9	17	6	16
Lowest offer	6.00 ct/kWh	5.34 ct/kWh	4.29 ct/kWh	3.86 ct/kWh
Highest offer	8.86 ct/kWh	7.47 ct/kWh	7.20 ct/kWh	5.74 ct/kWh
Number of offers receiving funding	38	32	20	24
Amounts receiving funding	200 MW	201 MW	222 MW	201 MW
Lowest price awarded	6.00 ct/kWh	5.34 ct/kWh	4.29 ct/kWh	3.86 ct/kWh
Highest price awarded	6.75 ct/kWh	5.9 ct/kWh	5.06 ct/kWh	4.59 ct/kWh
Average price awarded	6.58 ct/kWh	5.66 ct/kWh	4.91 ct/kWh	4.33 ct/kWh

Source: BNetzA

to 3.82 ct per kWh in the third auction round in 2017. In this auction, the lowest awarded price was 3.80 ct per kWh and the highest was 3.82 ct per kWh. The resulting level of funding ranges between 3.40 ct per kWh (at a 120% site), and 4.93 ct. per kWh (at a 70% site). In both auction rounds that have taken place thus far in 2018, the number of offers submitted and the energy amounts were down. On 1 February 2018 132 offers for 989 MW were submitted for an audit volume of 700 MW. On 1 May there were 111 offers for 604 MW for an audit volume of 670 MW. The average volume-weighted price awarded in the first round went up to 4.73 ct/kWh in the first round, and 5.73 ct/kWh in the second round. Accordingly, the price was at the level of the May 2017 auction. This is the first time that less volume was bid than was put up for auction. More information can be found in Table 4.3. A large number of awards in 2017 was concentrated in East Germany. As shown in solar auctions, this shows that, in addition to quality of sites, the availability of space is important in project development. More than 90% of awards from the first two audits were granted to citizens' energy companies that were allowed to participate in the auctions under less stringent requirements. Costs were kept low by the extended realisation period for citizens' energy companies that allowed bidders to consider cost and profit advantages of the next generation of technology when setting prices. The success of citizens' energy companies that are in an early planning stage, most without an emissions authorisation, has the effect that the additional capacity for projects receiving grants in 2017 is not expected until 2021/2022, if the projects are approved. This may reduce the probability that these installations will be realised. In both of the auctions conducted thus far in 2018, the privileges of citizens' energy companies were curtailed compared with auctions in 2017. Citizen wind generation projects were allowed to participate in the auction only with wind projects that were already authorized.

Table 4.3: Results of the first auction for onshore wind powered installations under the EEG

Auctions in 2017					
Auction date	1 May 2017	1 August 2017	1 November 2017	1 February 2018	1 May 2018
Number of offers received	256	281	210	132	111
Volume offered	2,137 MW	2,927 MW	2,591 MW	989 MW	604 MW
Excluded offers	12	14	15	2	–
Lowest offer	4.20 ct/kWh	3.50 ct/kWh	2.2 ct/kWh	3.82 ct/kWh	4.3 ct/kWh
Highest offer	7.00 ct/kWh	6.45 ct/kWh	6.66 ct/kWh	5.28 ct/kWh	6.28 ct/kWh
Number of offers receiving funding	70	67	61	83	111
Amounts receiving funding	807 MW	1,013 MW	1,000 MW	709 MW	604 MW
Lowest price awarded	5.25 ct/kWh	4.16 ct/kWh	2.2 ct/kWh	3.8 ct/kWh	4.3 ct/kWh
Highest price awarded	5.78 ct/kWh	4.29 ct/kWh	3.82 ct/kWh	5.28 ct/kWh	6.28 ct/kWh
Average volume-weighted price awarded	5.71 ct/kWh	4.28 ct/kWh	3.82 ct/kWh	4.72 ct/kWh	5.73 ct/kWh

Source: BNetzA

- Offshore wind energy: in the auction round conducted in early 2017, four offshore wind farms with 1,490 MW were awarded. The average mean value of the awards was 0.44 ct/kWh. Three awards were given for 0 ct/kWh, and one wind farm was awarded 6 ct/kWh. The awards involve projects in the North Sea Clusters 1, 3 and 7 that will go online in 2023. Awards of 0 ct/kWh means that these projects do not require funding.

- In the second auction round (1 April 2018), six awards were granted with a volume of 1,610 MW. The level of competition was somewhat lower than in the first round, because only existing projects could take part for which there was still network capacity available, and that had not been awarded a contract in the first round. Furthermore, a new restriction came into effect stipulating that at least 500 MW be awarded for projects in the Baltic Sea ("Ostseequote"). The average volume-weighted price awarded in the second round was 4.66 ct/kWh. The highest offer receiving an award was 9.83 ct/kWh. Two awards were granted at 0 ct/kWh. The median volume-weighted price awarded in both rounds was 2.3 ct/kWh.

Biomass remains the exception: the first auction for biomass installations differed from the auctions for solar and wind energy with regard to the participants and the results. Existing power plants subject to the previous funding limit of eight years were admitted to the auction and were granted a ten-year follow-on funding. In contrast to oversubscribed wind and solar energy auctions, biomass auctions were less competitive. Costs were lowered, however, the reductions achieved in wind and solar energy are not possible, due to operational and raw materials costs. In September 2017, 122 MW were auctioned. In total, the Federal Network Agency received 33 bids with a total volume of 41 MW. Twenty-four offers with a volume of 27.551 MW received funding, approximately 78% of this was awarded to existing installations. New installations with installed power exceeding 150 kW were admitted to the auction. The average award amount for all offers was 14.30 ct/kWh. The lowest awarded price for new installations was 14.81 ct/kWh and for existing installations, 14.16 ct/kWh. Additional auctions take place annually, on 1 September of each year.

Table 4.4: Results of the first auctions for offshore wind powered installations under the Offshore Wind Energy Act

Auctions in 2017	Offshore wind powered installations	
Auction date	1 April 2017	1 April 2018
Number of offers receiving funding	4	
Amounts receiving funding	1,490 MW	1,610 MW
Lowest price awarded	0.00 ct/kWh	0.00 ct/kWh
Highest price awarded	6.00 ct/kWh	9.83 ct/kWh
Average price awarded (volume-weighted)	0.44 ct/kWh	4.66 ct/kWh

Source: BNetzA

Table 4.5: Results for the first auction for biomass under the EEG

Auctions in 2017	Biomass
Auction date	1 September 2017
Number of offers receiving funding	24
Amounts receiving funding	27.55 MW (of that, 77% existing installations >150kW and 22% new installations)
Lowest price awarded	9.86 ct/kWh
Highest price awarded	16.9 ct/kWh
Average price awarded (volume-weighted)	new installations: 14.83 ct/kWh existing installations ≤150 kW: 16.9 ct/kWh existing installations >150 kW: 13.88 ct/kWh

Source: BNetzA

Transparency and participation: landlord-to-tenant electricity will become more economically attractive.

The goal of landlord-to-tenant electricity funding is to help tenants participate directly in the energy transition and to provide additional incentives for installing solar power on residential buildings.

Landlord-to-tenant electricity is power that is generated in solar PV installations on the roof of a residential building and that is delivered to end users, in particular tenants of the building or of residential buildings and other buildings in the immediate vicinity without being transmitted through the power grid. The power not used by tenants is fed into the municipal power grid and compensation is paid for this power.

In contrast to electricity consumption from the grid, several cost components are waived for landlord-to-tenant electricity (e.g. grid charges and electricity tax). In addition, in the future each kilowatt hour of landlord-to-tenant electricity will be subsidized – with a landlord-to-tenant electricity premium – financed with the renewable energy surcharge. The direct and indirect financial incentives make it economical for landlords, and tenants source their electricity from their "own" roof. Both parties help to promote expansion of renewable energy in the cities. There is quite a bit of potential: up to 3.8 million private accommodations could be supplied with landlord-to-tenant electricity.

Up to now, however, landlord-to-tenant electricity was not usually attractive, partly because in landlord-to-tenant electricity models there are substantial expenses for distribution, metering and invoicing. The landlord-to-tenant electricity premium will make landlord-to-tenant electricity more attractive in the future.

At the same time, the landlord-to-tenant electricity act creates the framework for enabling tenants to profit from low electricity prices, because they can still freely choose their electricity provider (competition).

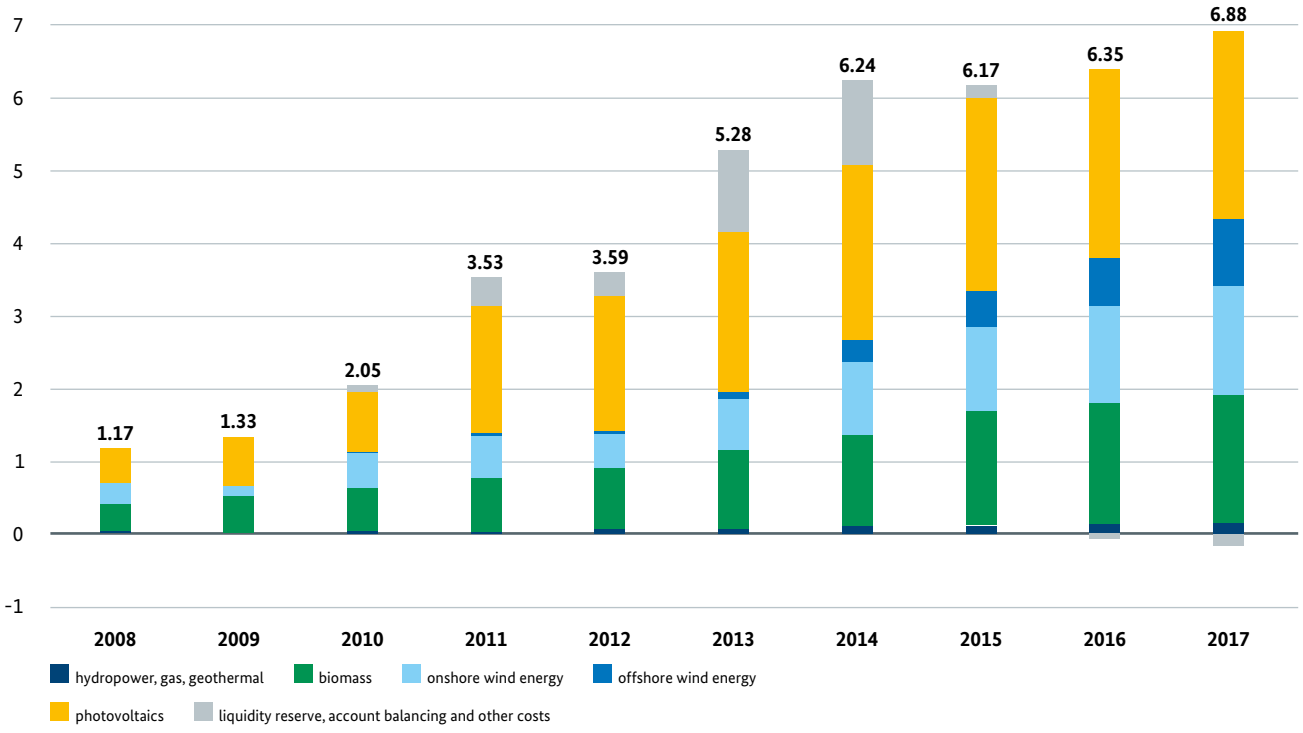
Financing for existing renewable energy plants continued to increase in 2016. The financing need is equivalent to the difference between remuneration or premium payments to the operators of RES plants under the Renewable Energy Sources Act and revenues from the sale of electricity from renewables on the electricity exchange. The prices and revenues on the electricity exchange fell in 2016, a development caused, inter alia, by the oversupply of power plant capacity and low demand for electricity in Europe. Renewables have themselves also contributed around 1 ct/kWh to the drop in prices on the electricity exchange on account of their low marginal costs (known as the merit-order effect). This is reflected in a slight increase in the cost of financial support, rising from €21.9 billion in 2015 to €22.2 billion in 2016. Remuneration for existing RES plants is based on guaranteed feed-in tariffs for periods of up to 20 years. Even in view of the results of the first auction, it is expected that new installations will continue to offer cost-saving potential as a result of advancements in technology and thereby drive down the rates of remuneration under the Renewable Energy Sources Act. The need to finance RES is set against the positive impact of renewables, such as avoided emissions of greenhouse gases and atmospheric pollutants and the resulting reduction of harmful effects on health and the environment. In addition, the expansion of renewables produces macroeconomic benefits: for example, less use of fossil fuels causes energy imports to fall (see Chapter 3 and 8). In addition, the promotion of renewables in Germany through the Renewable Energy Sources Act and beyond has also contributed at an international level to a reduction in technology costs in the field of renewable energy.

The EEG surcharge in 2018 is 6.792 ct/kWh. This is a slight decrease of 0.09 ct/kWh over the previous year. The surcharge has ranged between 6.2 and 6.9 ct/kWh since 2014. Previous to that, it climbed drastically (from 3.59 ct/kWh in 2012 to 6.24 ct/kWh in 2014). The EEG surcharge has inherited a large cost burden from the past, specifically payment for existing installations with high feed-in tariffs which cannot be altered due to the principle of the protection of legitimate expectations and the protection of vested interests. New installations require much lower feed-in tariffs, which will substantially reduce the load on the EEG surcharge in the long run (see Diagram 4.10).

Owing to the EEG reforms in 2014 and 2017, it was possible to limit the increase in the EEG surcharge and at the same time, to promote renewable energy expansion. It has therefore been possible to slow down the cost dynamics of previous years appreciably. At the same time, the share of renewable energy sources in electricity consumption grew more rapidly than ever before – to 25% in 2013, and to around 36% in 2017 (AGEE-Stat/AGEB). There has not been an increase of 11% in any parliamentary term since the EEG became law.

Diagram 4.10: EEG surcharge by technology segment

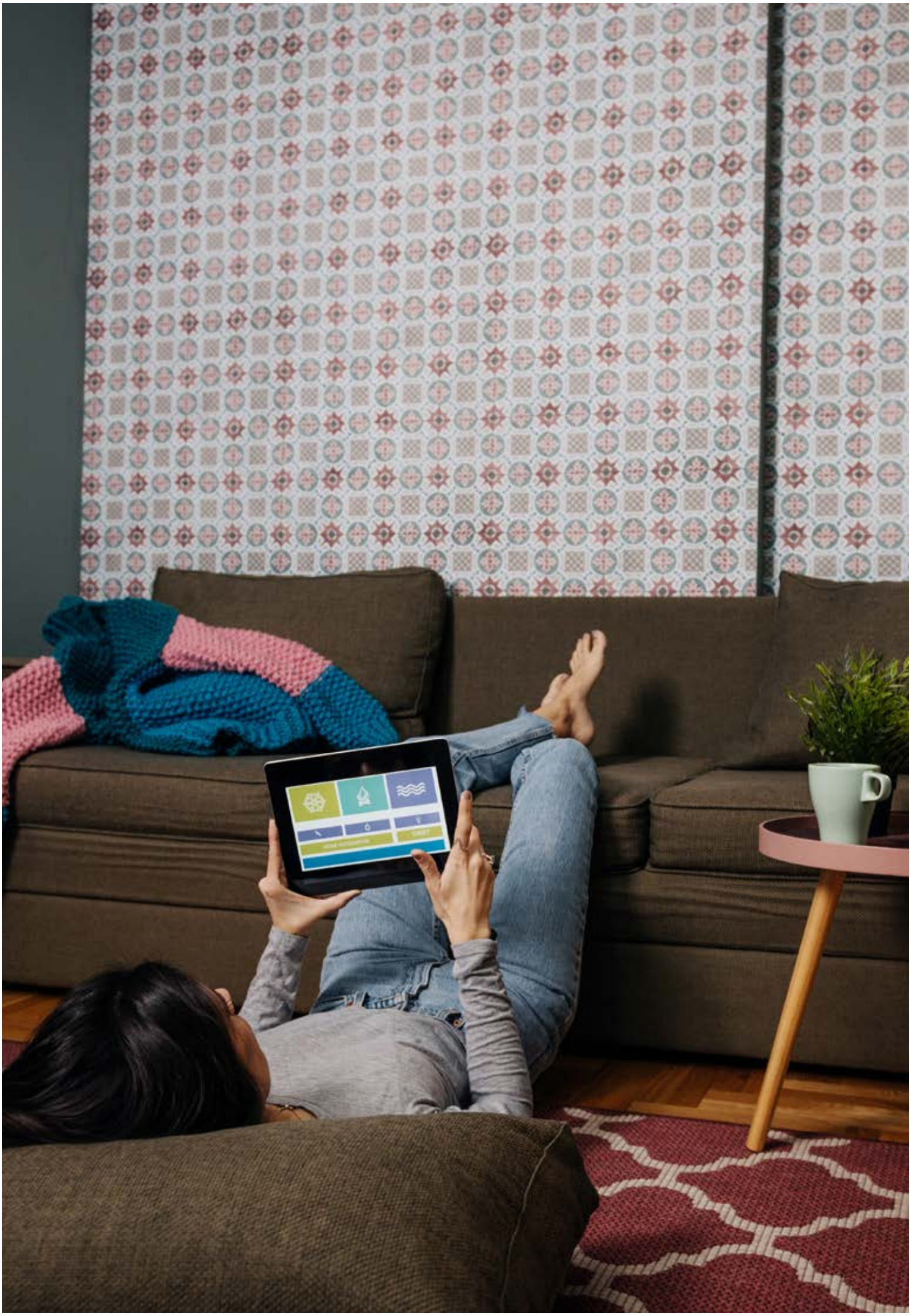
in ct/kWh



Source: Federal Ministry for Economic Affairs and Energy on the basis of the forecast prepared by the transmission system operators in accordance with the Equalisation Scheme Ordinance

Central measures for renewable energy in the electricity, heating and transport sectors

- Renewable Energy Sources Act 2017
- Act to Revise the EEG 2017
- Landlord-to-Tenant Electricity Act
- 2015 Revision of the Market Incentive Programme (see Chapters 5 and 6)
- Harmonised regulatory system for the heating market (see Chapter 5)
- Measures regarding electric mobility/biofuels/ rail transport (see Chapter 7)
- Promotion of heat pumps
- Low-temperature heat networks with seasonal thermal energy storage



5 Energy consumption and energy efficiency

Where do we stand?

Primary energy consumption rose in 2016 by 1.4% compared with the year before. Strong economic growth, the relatively cool weather compared with the previous year, and the additional leap day (2016 was a leap year) were factors. According to preliminary estimates, primary energy consumption rose again slightly in 2017.

The measures proposed by the National Action Plan on Energy Efficiency (NAPE) and the energy policy resolutions of 1 July 2015 have been instigated and are starting to show results. In 2016, a tendering framework for efficiency measures (STEP up!) and the Energy Savings Meters pilot programme were initiated.

Annual energy savings of 0.8% on average since 2008 are not sufficient to reach the target set for 20% reduction by 2020. To do this, in the years remaining until 2020, the entire German electricity consumption would have to be conserved. Such a reduction by 2020 is unlikely. Overall, there is a great need take action to achieve the savings target as quickly as possible.

What is new?

With its Green Paper on Energy Efficiency, the Federal Government has launched consultative processes that look to promote energy efficiency policies. The next step is to develop an efficiency strategy for the Federal Government. The “Efficiency First” principle is to be established as the guiding principle for energy policy.

The German Federal Government has initiated an assistance programme titled “Energy Efficiency and Heating with Renewable Energy” to simplify funding programmes and cut red tape.

	2016	2020	2030	2040	2050
Efficiency and consumption					
Primary energy consumption (compared with 2008)	-6.5%	-20% →			-50%
Final energy productivity (2008–2050)	1.1% per year (2008–2016)	2.1% per year (2008–2050)			
Gross electricity consumption (compared with 2008)	-3.6%	-10% →			-25%

5.1 Primary energy consumption and primary energy productivity

Primary energy consumption rose in 2016 compared with the year before. In 2016, primary energy consumption stood at 13,451 PJ, up 1.4% on the previous year (Diagram 5.1). Contributing to the increase was both strong economic growth of 1.9% as well as an increase in the population of about 662,000 persons. In addition, 2016 was a leap year with an additional day on which energy was consumed, which added 0.3 percentage points to the increase in primary energy consumption. In addition, the cooler weather conditions compared with the previous year led to increased consumption, because a substantial portion of primary energy is used for room heating. Following adjustments for the effects of temperature and inventories, primary energy consumption energy consumption in 2016 was 1.2% higher than the previous year. The rise in consumption due to the economy, the leap day and population growth could only partially be counteracted by increases in energy efficiency.

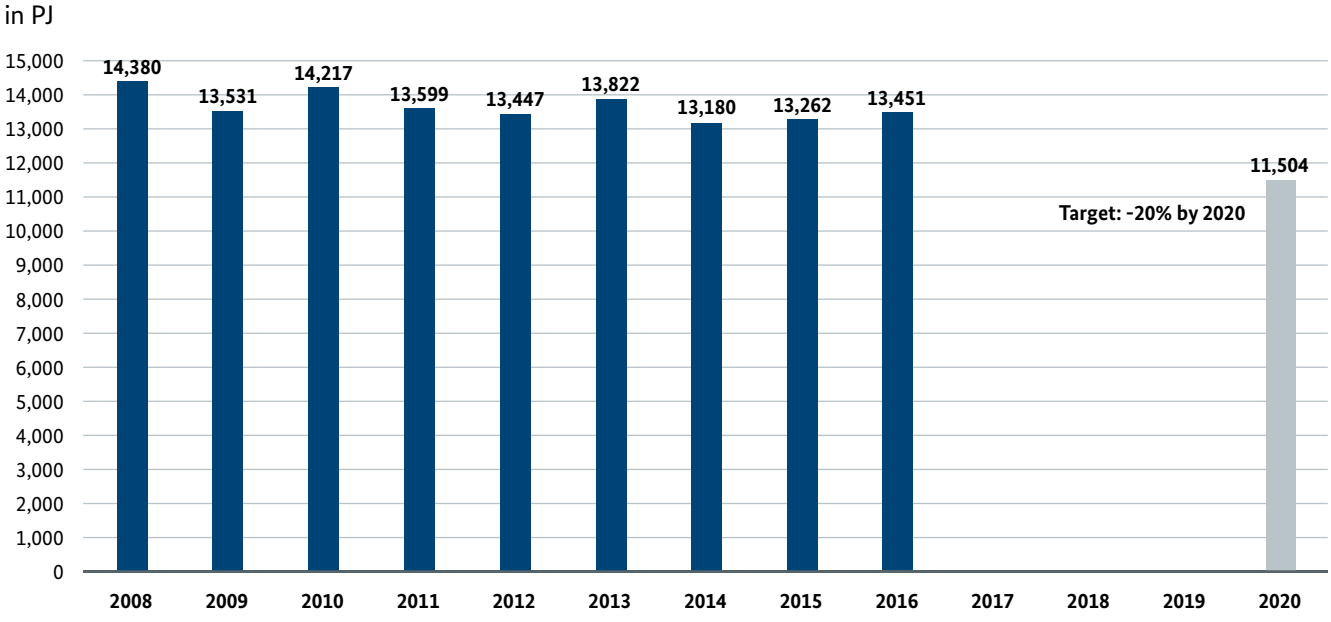
The demand for renewable energy and natural gas increased again significantly in 2016. Petroleum was also in higher demand. In contrast, the consumption of coal, lignite and nuclear declined. Another comparatively cold winter in 2016 contributed to the higher demand for natural gas, as in the previous year, particularly in the heating market. However, heavier use of natural gas for electricity generation also contributed to this increase.

Compared with the reference year (2008), primary energy consumption in Germany had dropped by 6.5% in total in 2016. In order to reach the reduction target for primary energy consumption by 2020, this consumption would have to be further reduced by 13.5% compared with the level of 2016. In absolute numbers, this is the equivalent of around 2,000 PJ, that is, the entire German annual electricity consumption. Such a decline by 2020 is unlikely. The following comparison also makes this clear: primary energy consumption has dropped by 0.8% annually since 2008. In order to reach the 2020 reduction target, consumption would have to be reduced by 3.8% annually from now on – the reduction rate would have to increase by a factor of almost five. Overall, there is a great need take action to achieve the savings target as quickly as possible. Even so, it should be noted that even new immediate actions would require a certain period of time to take effect.

The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of cutting primary energy consumption by 20% compared with 2008 will be missed by a wide margin. The study

Diagram 5.1: Meeting the primary energy consumption target

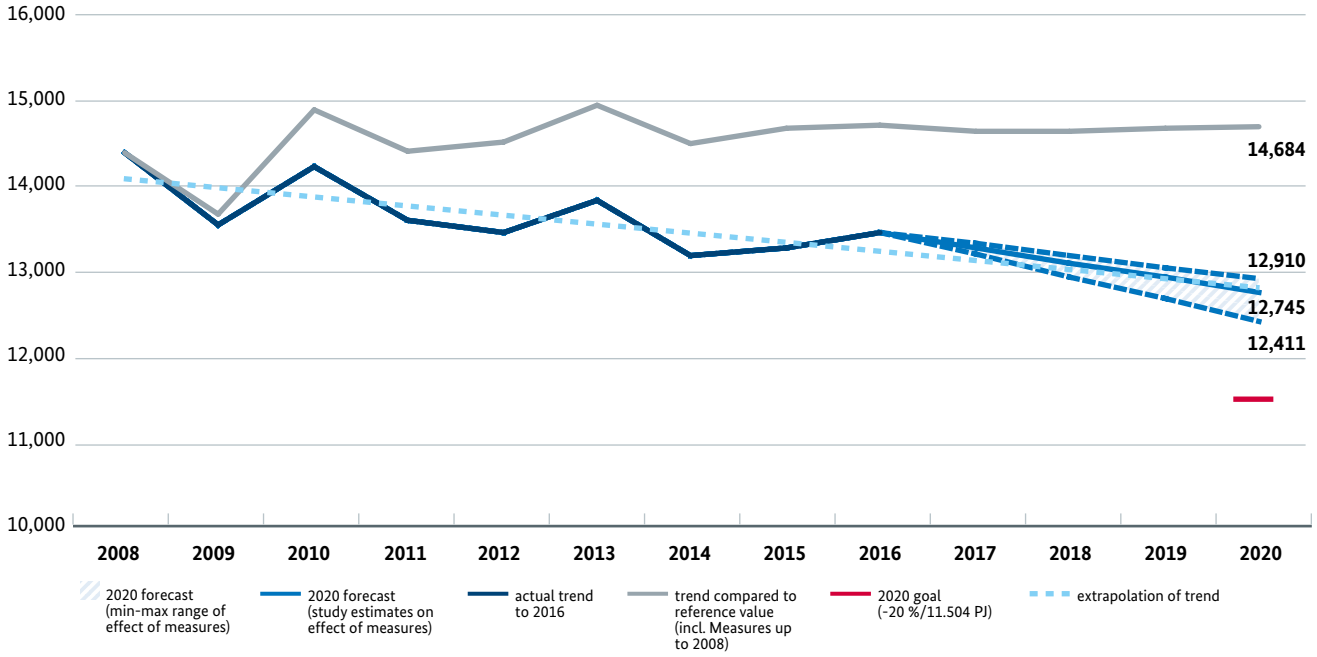
2020 target	20% reduction in primary energy consumption (compared with 2008)
Status in 2016	-6.5%



Source: AGEB 08/2017

Trend	●●○○○
Measures	National Action Plan on Energy Efficiency and other existing energy efficiency programmes

Diagram 5.2: Reduction of primary energy consumption according to the Target Architecture Study
in PJ



Source: Prognos, Fraunhofer ISI, DLR (2018)

assumes that this reduction will be at about only 11.4% by 2020 (within a range of 10.2% to 13.6%, see Diagram 5.2). This takes the effects of measures taken under the Target Architecture Study into account.

According to preliminary estimates, primary energy consumption rose again slightly in 2017. This follows from the annual report of the Working Group on Energy Balances (AGEB 2018). According to this report, primary energy consumption in 2017 was at around 13,550 PJ. The reasons for this were again the strong economy, cooler weather conditions in early 2017 compared to the previous year, and another population increase. Considering the development of individual energy sources at the generation level, good wind condition on- and offshore as well as a slightly higher number of hours of sunshine led to a continued increase in electricity feed-in from renewable energy. Of conventional energy sources, the increase was highest for natural gas. The main reason was the increased utilization of natural gas in power plants for generating electricity. In contrast, use of black coal went down, primarily because this energy source was replaced with natural gas and renewable energy for electricity generation.

In addition to absolute energy consumption, how efficiently a national economy uses energy is also of central importance. Energy efficiency is one indicator of this. To determine energy efficiency, it is necessary to calculate the ratio of a country's economic output (e.g. gross domestic product or gross value added) to energy consumption. Energy productivity therefore indicates the value of goods and services that can be produced with one unit of energy.

Primary energy productivity has increased slightly on the previous year. In 2016, it was possible to produce 0.5% more products and services with the same amount of energy compared with the previous year (see bottom curve in Diagram 5.3). Adjusted for the effects of the weather as well as changes in inventories, the increase was 0.8%.

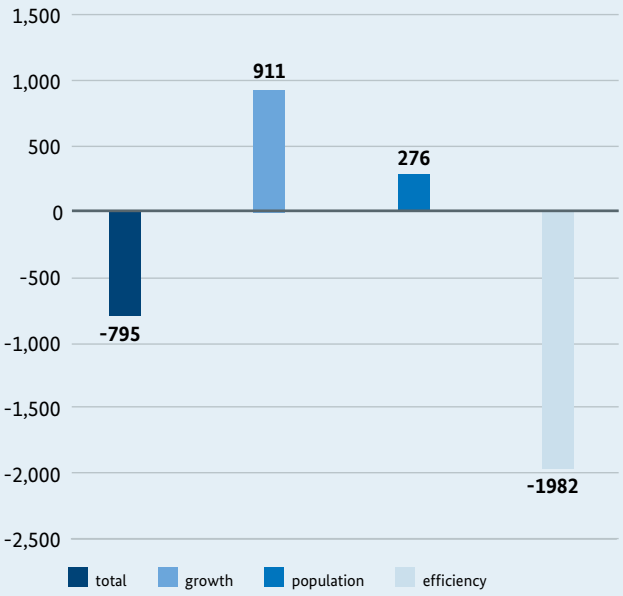
Factors influencing energy consumption

The changes in primary energy consumption are attributable to a number of factors. Apart from weather conditions, the most important determinants are the development of the population (demographic component), the change in GDP (growth component) and macroeconomic energy intensity (energy intensity component). By analysing the components using the decomposition model proposed by Sun (1998), for example, it is possible to draw conclusions about the contribution of the individual factors influencing the development of primary energy consumption. The individual contributions quantify the change in total energy consumption that would occur, in theory, if just one of the components were to change while all the other factors remained constant.

The result, after adjusting for temperature differences, is that the overall decrease of 795 PJ in energy consumption between 2008 and 2016 is largely attributable to improvements in energy efficiency. In contrast, the positive economic developments during this period had the effect of increasing energy consumption. Taken in isolation, the total population increase of around 1.6 million people in the period between 2008 and 2016 also drove up energy consumption slightly. Component decomposition illustrates that efficiency efforts made during the 2008-2015 period overcompensated for effects that drove up consumption, such as increasing per capita income and population growth. Calculations made by the European Commission for individual consumption sectors between 2005 and 2015 confirm this (COM-1). These results show, for example, that in the industry sector and in the crafts, trade and services (CTS) sector, the increase in final energy consumption between 2005 and 2015 was in particular due to a rise in economic activity. The European Commission results also indicate that this increase was counteracted by an improvement in energy intensity in the industry and CTS sectors and a slight shift to less energy intensive processes (structural effect) in the same period.

Diagram 5.3: Components influencing the change in adjusted primary energy consumption in Germany in the period 2008–2016

in PJ



Source: Federal Ministry for Economic Affairs and Energy, in-house representation based on data from the Working Group on Energy Balances, 11/2017

5.2 Final energy consumption and final energy productivity

Final energy consumption has increased compared with the preceding year. Final energy is the share of primary energy that is available to consumers after deductions for energy lost during transmission and conversion. In 2016, final energy consumption was 9,152 PJ, 2.8% higher than the previous year. Following adjustments for the effects of temperature and inventories, final energy consumption in 2016 rose 2.9% on the previous year. Broken down by sector, households were responsible for 4.0%, the largest growth in final energy consumption, then trade and services with 3.7%, and transport with 2.9%. The increase in the industry sector was 1.3%.

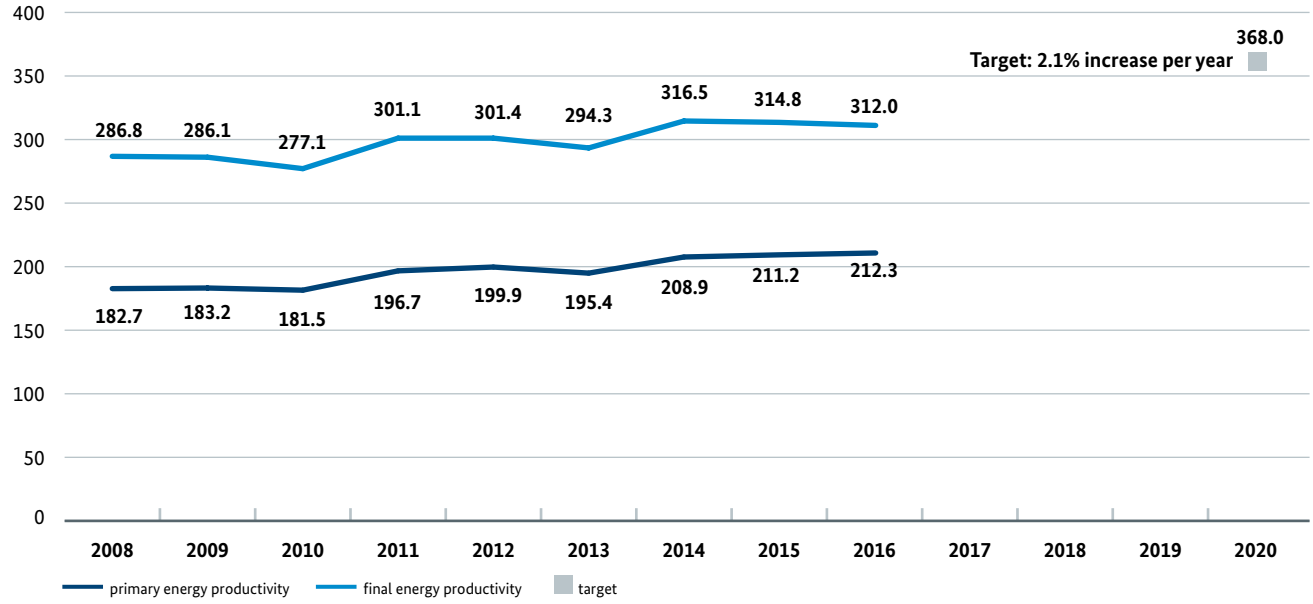
If we look at the individual energy sources, growth was strongest in natural gas consumption, at 6.9%. Consumption of fuels grew by 3.0%, and district heating grew by 1.4%. In addition, 1.0% more black coal was consumed than in the previous year. On the other hand, consumption of heating fuel dropped significantly, by 5.1%.

Final energy productivity dropped slightly in 2016. The Federal Government's Energy Concept also refers the efficiency goal to final energy productivity, i.e. to the real gross domestic product per unit of final energy consumption. Final energy productivity stood at €312.0/PJ in 2016 compared with €314.8/PJ the previous year, a decrease of around 0.9% (see top curve in Diagram 5.4).

Diagram 5.4: Meeting the energy productivity target

2020 target	Increase final energy productivity by 2.1% per year
Status in 2016	1.1% annually since 2008

in Euro/GJ



Source: Working Group on Energy Balances, 08/2017

Trend	●●●○○
Measure	National Action Plan on Energy Efficiency

Transparency and participation: energy efficiency – many possibilities for participating in the energy transition

Particularly in the area of energy efficiency there are many options for citizens, companies and municipalities to actively shape the energy transition and to benefit from it. The Federal Government provides ample funding for companies, municipalities and households. The Federal Ministry for Economic Affairs and Energy has access to €17 billion for existing and new energy efficiency measures during the period 2016-2020. Of this, €2.5 billion are earmarked for NAPE activities for this same period. Even smaller measures, for example in buildings, are eligible for investment grants or loans, which makes the energy savings they generate financially attractive.

In the summer of 2016 the Federal Ministry for Economic Affairs and Energy published the Green Paper on Energy Efficiency, instigating a broad consultation procedure with all participants in society on mid- and long-term development of energy efficiency policy. From mid-August to the end of October 2016, the Green Paper was discussed in various formats: comments were submitted and a number of dialog events were held, as well as online consultation. The "Efficiency First" principle is to be established as the strategic guiding principle for energy policy. The next step is to develop options for a mid-term to long-term efficiency strategy for the Federal Government. This is also provided for in the 2050 Climate Action Plan.

In May 2016 a broad-based campaign was launched to boost energy efficiency. The "Germany Makes it Efficient" awareness-raising and mobilisation campaign is aimed at informing all the stakeholders about the joint project that is the energy transition, and convincing them of the need for yet more efficient use of energy. The campaign is geared to private households, business enterprises and public institutions alike, and involves all the stakeholders in a stakeholder dialogue. The Ministry for Economic Affairs and Energy will set up a project office to this end.

Between 2008 and 2016, final energy productivity increased by 1.1% on average each year, which clearly falls short of the target of an annual increase of 2.1%. Final energy productivity would have to increase by an average of 4.2% annually in the four years between the reporting year 2016 and 2020 to achieve the pre-determined target set by the Energy Concept. This would be equivalent to an increase in growth rates of previous years by a factor of almost four. This acceleration is very unlikely. However, the goal is still to produce the real GDP with as little final energy consumption as possible and to avoid unnecessary energy consumption. For this reason, companies, households and the public sector must continue to focus on efficient handling of energy resources.

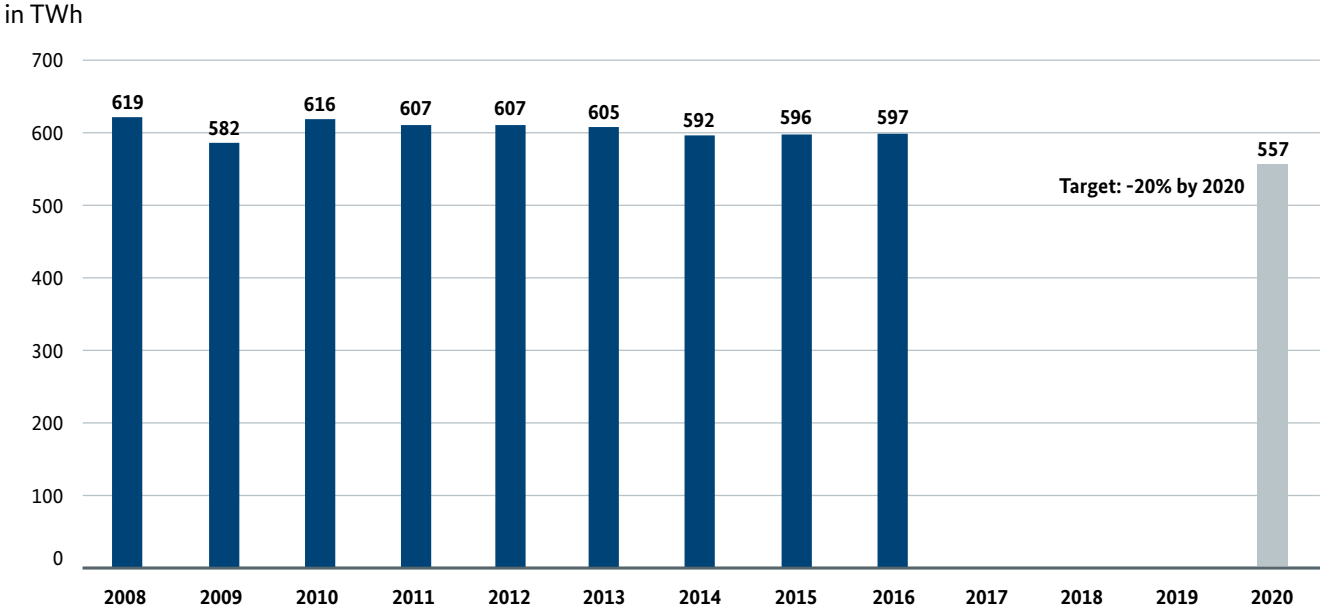
5.3 Electricity consumption and electrical energy efficiency

Gross electricity consumption stayed fairly constant in 2016 compared to the previous year. Gross electricity consumption refers to the volume of electricity consumed in Germany. In 2016, this figure was around 597 TWh (Diagram 5.5). Efficiency gains were able to compensate for factors leading to increased consumption – strong economic growth and population growth – however, they did not cause any significant reduction in consumption.

Between 2008 and 2016, gross electricity consumption declined by around 3.6%, an average decline of about 0.5% annually. In order to reach the reduction goal by 2020, electricity consumption would have to go down by an average of 1.7% annually from 2016 to 2020. The rate of reduction would have to more than triple – which is unlikely. When putting this in numbers, the remaining difference between present consumption and the target is about 40 TWh, roughly equivalent to the annual electricity output of four atomic energy plants. Here we must take into consideration

Diagram 5.5: Meeting the electricity consumption target

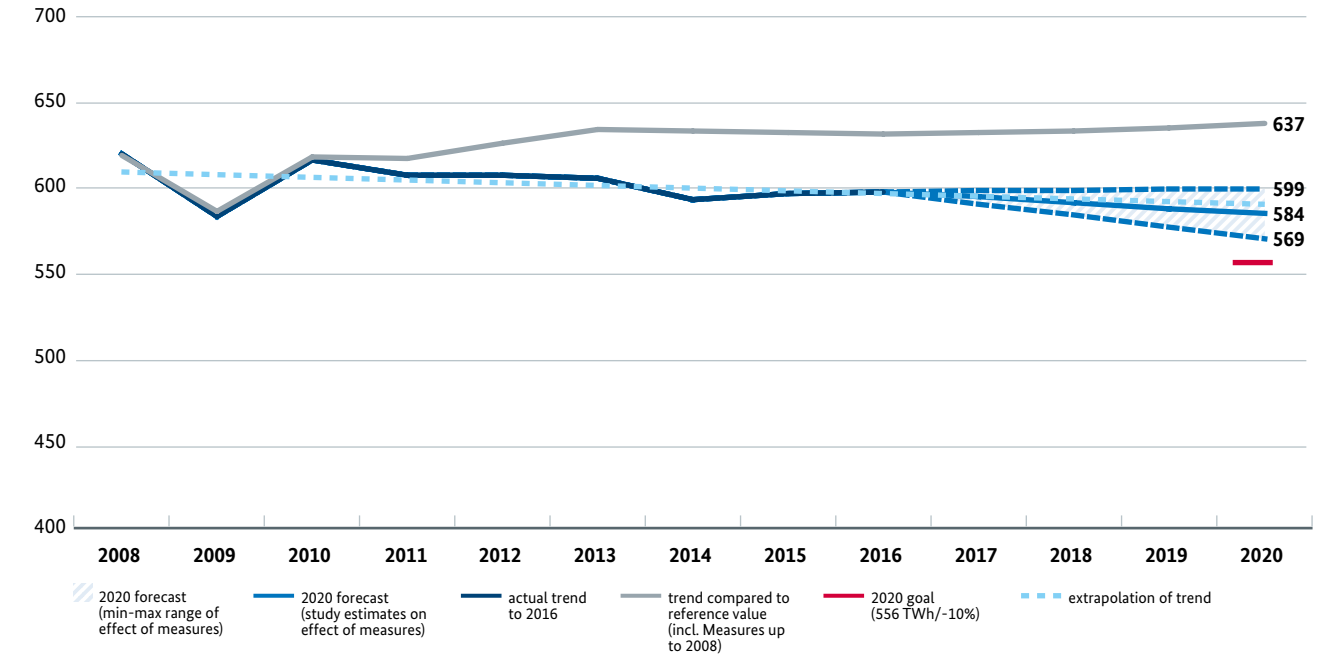
Target 2020	Reduce gross electricity consumption by 10% by 2020 (compared with 2008)
Status in 2016	-3.6%



Source: Working Group on Energy Balances, 12/2017

Trend	●●○○○
Measures	National Action Plan on Energy Efficiency

Diagram 5.6: Reduction of gross electricity consumption according to the Target Architecture Study
in TWh



Source: Prognos, Fraunhofer ISI, DLR (2018)

that, if we are to make further progress with decarbonisation in the heating and transport sectors, increasing amounts of green electricity should be used efficiently in these sectors within the context of sector coupling. This creates new energy consumers. To keep the additional need for renewable electricity to a minimum, sector coupling should always use the technologies that efficiently convert electricity to heat, cold or propulsion energy, and thereby replace the largest possible amount of fuel with a small amount of renewable electricity (see Chapter 13.1).

The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of cutting gross electricity consumption by 10% compared with 2008 will be missed by a wide margin. The study assumes that this reduction will be at about -5.5% by 2020 (within a range of -3.1% to -7.9%, see Diagram 5.5). This takes the effects of measures taken under the Target Architecture Study into account.

Macroeconomic electricity productivity increased again in 2016. Macroeconomic electricity productivity expresses the ratio of real GDP to total gross electricity consumption and is therefore an indicator of how efficiently an economy uses electricity. In 2016, it registered an increase of 1.8% on the previous year. There has been a trend towards greater decoupling of economic growth from the development of electricity consumption ever since the 1990s. In 2016, aggregate electricity productivity was more the one-third higher than the 1990 level, and increased by around 1.2% on average each year during this period.

5.4 National Action Plan on Energy Efficiency

With the National Action Plan on Energy Efficiency (NAPE), the Federal Government in 2014 launched a comprehensive strategy to deliver on the energy consumption goal. NAPE defines immediate actions and farther-reaching work processes in order to meet the national efficiency and climate goals. It also makes a significant contribution to the 2020 Climate Action Programme.

The most important action areas of energy efficiency policy are to:

- Step up energy efficiency in the buildings sector
- Establish energy efficiency as a business model and a model for generating returns on investment
- Increase personal responsibility for energy efficiency

To do this, NAPE defines cross-sector measures designed to reduce energy consumption. The goal was to utilise NAPE measures to boost energy efficiency to save 390–460 PJ of energy in total primary energy by 2020.

Programmes based the resolutions of the party leaders of the coalition of CDU, CSU and SPD passed on 1 July 2015 flesh out NAPE. These measures aim to cut an additional 5.5 million tonnes of CO_2 through energy efficiency measures in buildings, the municipalities, in industry and at German rail provider Deutsche Bahn AG.

The measures proposed by NAPE and the energy policy resolution of 1 July 2015 have already been introduced and are starting to show results. The tax incentive proposed by NAPE for building refurbishment could not be implemented because no agreement was reached with the Länder. As a substitute, the Federal Energy Efficiency Incentive Programme (incentives in the buildings sector) was provided with 42.5% funding, the portion of Federal financing intended for the original tax incentive.

In 2016 all of the programmes for which there is data have achieved a reduction of about 11 million tonnes of CO_2, which is about 140 PJ of primary energy savings. These comprise both new savings from efficiency measures carried out in 2016, as well as savings in 2016 resulting from earlier energy-efficiency work (this is called the NAPE logic). A direct comparison with projected effects of NAPE is not possible because in some cases they reflect the increased funding of only some of the programmes. This applies in particular to the CO_2 building renovation programme. Table 8.1 shows the effects of NAPE measures projected for the period to 2020.

The direct and indirect savings resulting from energy efficiency instruments are sometimes not easy to quantify. In particular, it is hard to assess how awareness raising really affects the actions of stakeholders. In addition, awareness raising and advisory efforts often initially have an indirect effect when combined with other measures or actually trigger specific energy efficiency investments. Significant methodology challenges and various methodology approaches arise also when quantifying deadweight effects multiplier and overlap effects. Overlap effects, that is counting savings twice, should be avoided. This happens anytime a conserved unit of energy is counted both under the indirect effects of an awareness and activation measure and under the direct effects of a funding programme (e. g. building insulation).

Due to differing commencement periods, methods of effectiveness, and the early stages of development of the individual efficiency measures, their effectiveness is often unevenly exploited. For a number of measures, especially those that were initiated in 2016, verifiable data is still lacking in some areas. Many of these measures have only taken effect recently and are still in the initial phase, such that they are not currently achieving their average (full) annual savings.

Table 5.1: Effects of NAPE in 2016 that have been quantified up to now

NAPE measure and programmes on the basis of the resolutions of the party leaders of the coalition of CDU, CSU and SPD passed on 1 July 2015	Primary energy savings (in PJ)	CO_2 savings (cumulated in kilo tonnes of CO_2 equivalent)
	2016	2016
NAPE measures (only those with quantifiable primary energy savings in 2016)		
CO_2-Building Modernisation Programme: residential buildings	101	7,683
CO_2-Building Modernisation Programme: non-residential buildings	not specified	466
Energy Efficiency Incentive Programme (APEE), measures carried out by KfW (Reconstruction Loan Corporation) and BAFA	2	142
National Efficiency Label for old heating systems	0.02	133
Market Incentive Programme on Promoting Measures for Use of Renewable Energy in the Heating Market (MAP)	1	792
KfW Energy efficiency improvement Programme for Production Facilities and Processes	16	475
Energy Efficient Networks Initiative	1	36
Mandatory energy audits for non-SMEs	4	264
SME Energy Transition and Climate Action Initiative	1	37
Energy-efficient and Climate-smart Production Processes	3	183
National Top Runner Initiative (NTRI)	0.2	not specified
STEP up! “STromEffizienzPotenziale nutzen” (Utilize energy efficiency potential)	0.1	6
Funding guidelines for energy management systems	1	67
Energy consulting	5	325
Programmes on the basis of decisions made 1 July 2015		
Heating optimisation	0.03	2
Funding for horizontal technologies	6	359
Waste heat	0.78	52
Total effect	**140**	**11,022**

Source: Federal Ministry for Economic Affairs and Energy, 5/2018

We can assume that the effects of the new instruments will continue to strengthen in the course of their respective programme periods. As such, the total values listed in Table 7.1 for those measures with quantifiable results to date are not representative of the overall effectiveness of NAPE by 2020. More precise conclusions on NAPE effects are only possible over the coming years on the basis of current programme evaluations. NAPE monitoring will be more in-depth in the next few years. However, it is already expected that some of the measures will not completely reach their target levels.

The coalition agreement between the CDU, CSU and SPD for the current legislative term contains provisions for continuing to develop NAPE on the basis of the results of the Energy Efficiency Green Paper and to implement it as soon as possible. Existing programmes for funding energy efficiency are to be evaluated and, where needed, optimized to fit user needs. Funding should be consolidated at the current level.

Monitoring of central measures for funding energy savings measures

KfW Energy Efficiency Improvement Programme for Production Facilities and Processes		
Short description	The KfW Energy Efficiency Programme provides low-interest loans to industrial companies for energy efficiency measures in the area of production facilities and processes. Funding is provided for any investments that achieve energy savings of at least 10% (entry standard) or at least 0% (premium standard). Both upgrades and new investments in machines, plants, and process technology compressed air, vacuum and suction technology; electrical motors and pumps; process heat and cooling; heat recovery and waste heat recovery; measurement and control technology; information and communication technology, and combined heat and power plants. The maximum loan amount is usually €25 million per project. Loan maturities of 5, 10 or 20 years are possible.	
Current status	The KfW Energy Efficiency Programme for Production Facilities and Processes in its current form was started 1 July 2015. It was previously incorporated in the KfW Energy Efficiency Programme that also provided funding for building construction measures (new investments, refurbishing, building installation technology and heating and lighting). This type of funding was consolidated on 1 July 2015 into the KfW Energy Efficiency Programme for Energy Efficient Construction and Refurbishing (276, 277, 278).	
Type of instrument	Funding programme	
Target group	Companies	
Energy sources	All	
Launch of the instrument	2015	
Completion	KfW	
Evaluation and background information	Prognos AG funding data: KfW (additional data and estimates provided by Prognos AG); evaluation was completed in December 2017; funding is provided as a loan. On the basis of the available data it is not possible to determine profitability factors.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	16	30
Final energy savings (in PJ)	4	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	475	2,000

Energy Efficient Networks Initiative	
Summary	The goal of the Energy Efficiency Networks Initiative that is sponsored by the Federal Government together with currently 22 associations and business organisations is to initiate around 500 new Energy Efficiency Networks (EEN) in Germany by the end of 2020. Important industry sectors, the energy industry, the skilled craft sector and trade are involved in the initiative. The main thrust is to motivate companies to carry out significantly more efficiency measures by exchanging information through the network than they would on their own. Companies set savings targets at the beginning of their involvement in this network, both for themselves and for the joint initiative. Experienced energy advisors structure and assist in the network efforts.
Current status	• Since the inception of the measure 102 networks have been founded • An international workshop was held on 15 September 2016 (together with IPEEC) • First annual conference of the initiative on 20 September 2016 • Cooperation with the Länder and association members (workshop in Nuremberg on 22 September 2016) • Work on defining reduced standards for SMEs
Type of instrument	Voluntary commitment from business and industry
Target group	Industrial companies, trade and commercial companies
Energy sources	All

→

Energy Efficient Networks Initiative		
Launch of the instrument	3 December 2014	
Implementation	Contact with companies through associations and business organisations In some cases these entities also function as network initiators. The Federal Government provides funding specifically with public relations and financing an administrative office.	
Evaluation and background information	Annual monitoring starting late 2017 through the adelphi consortium and Fraunhofer-Institute for Systems and Innovation Research.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	1	75
Final energy savings (in PJ)	0.4	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	36	5,000

Mandatory energy audits for non-SMEs		
Short description	To increase energy efficiency of business, companies that are not small or medium-sized enterprises (non-SMEs) have been obligated since 22 April 2015 under the Energy Services Act to conduct an energy audit by 5 December 2012 and from then on to conduct further audits at least every four years. The Federal Government complied with Art. 8 paragraphs 4–7 of the Energy Efficiency Directive by introducing the audit requirement as part of NAPE.	
Current status	On-going implementation	
Type of instrument	Regulatory law	
Target group	Non-SMEs/associated companies	
Energy sources	All	
Launch of the instrument	1 May 2015, the first date by which an audit was required, or alternatively, an energy management system to ISO 50001 or EMAS by 31 December 2016	
Implementation	BAFA	
Evaluation and background information	Evaluation in the autumn of 2016 The BAFA conducts regular annual samplings during which approximately 500 companies are audited regarding their compliance with energy standards.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	4	51
Final energy savings (in PJ)	3	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	264	3,400

Funding for horizontal technologies	
Short description	The goal of funding investments in highly efficient horizontal technologies is to quickly tap the existing potential for efficiency improvements in industry and trade in generally applicable technologies. The funding programme thereby creates specific incentives for companies to invest in these technologies. Individual measures provide funding for electrical motors and powertrains, pumps, ventilators, compressed air systems and standard technologies for use of waste heat. Systemic measures provide support for updating at least one technical system in the technologies listed under individual measure. A prerequisite for systemic measures is participation in an energy advice programme. The funding rates range between 20% and 30%, according to company size. The funding rate for systemic measures is also dependent upon the verifiable amount of energy saved (at least 25%).
Current status	The programme will be continued without alteration in 2018. Up to now (since June 2016), around 8,000 applications for funding have been submitted and about €45 million of funding approved.
Type of instrument	Funding programme
Target group	Companies (especially SMEs)
Energy sources	All
Launch of the instrument	2012
Implementation	BAFA
Evaluation and background information	Evaluation was conducted by Fraunhofer ISI in 2016 in the context of the Energy Efficiency Fund. Prior to that there is an external evaluation (separately from the Energy Efficiency Fund) conducted by dena. Published in 2016.

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Funding for horizontal technologies		
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	6	not specified
Final energy savings (in PJ)	3	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	359	900
Projects financed (number per year)	3,125	At last 5,000 projects per year

Waste heat		
Short description	The goal of the funding programme for avoiding waste heat and to recover waste heat in industrial companies (waste heat programme) is to save 1 million tonnes of CO_2 annually by 2020. The programme serves to implement the Waste Heat Prevention Campaign, part of NAPE Funding is provided for investments in replacement, modernisation, expansion or new construction of facilities that prevent waste heat or efficiently utilize previously unused waste heat, both inside and outside the plant. Assistance is provided either as a subsidy or as subsidies for redemption of principal of a KfW loan. To receive funding, companies must present a plan for recovery of waste heat prepared by a certified energy advisor. Loans with redemption subsidies (subsidy: 30%-40% of the investments qualifying for funding; 10% bonus for SMEs).	
Current status	On-going implementation. The programme was initiated in 2016 and, after an initial period of getting started, is currently very popular. According to an evaluation conducted by Fraunhofer-Institute for Systems and Innovation Research in March 2018, an annual savings of 937 kt of CO_2 can be expected.	
Type of instrument	Funding programme	
Target group	Companies	
Energy sources	Electricity and fuels	
Launch of the instrument	2016	
Implementation	KfW	
Evaluation and background information	Initial calculations with detailed data from Waste Heat Monitoring (dena) taken in only 39 instances	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	1	not specified
Final energy savings (in PJ)	1	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	52	1,000

SME Energy Transition and Climate Action Initiative		
Summary	The SME Energy Transition and Climate Action Initiative has provided funding since 1 January 2013 to companies implementing the energy transition and offers SMEs in the craft trades and industry specific assistance with qualifications building and network projects for energy efficiency and climate protection. Companies receive specific assistance through optimization of information and advice as well as by stepping up further training, qualifications building and exchange of information. The initiative is a joint project sponsored by the Federal Ministry for Economic Affairs and Energy, the Federal Ministry for the Environment (BMU), the Association of German Chambers of Industry and Commerce (DIHK) and the German Confederation of Skilled Crafts and Small Businesses (ZDH). The Federal Ministry for Economic Affairs and Energy and the Federal Ministry for the Environment each provided 50% of funding for the project, drawing from the Energy and Climate Fund, and 20% came from the project partners. To avoid mix funding, the German Association of Chambers of Industry and Commerce projects are funded by the BMU, and the ZDH projects by the Federal Ministry for Economic Affairs and Energy.	
Current status	The first funding phase ended on 31 December 2015. The next phase of the SME Initiative was launched on 1 January 2016 as a seamless continuation of the previous project. This SME Initiative 2.0 is a joint project of the BMU and the BMWi, just as the previous project was. The seven development workshops have already been converted into transfer workshops that transfer the knowledge gained to new transfer partners. The Energy Book was completed and is now available to skilled craft trades.	
Type of instrument	Funding programme	
Target group	Company (SMEs, skilled crafts businesses)	
Energy sources	Electricity, fuels	
Launch of the instrument	2013	
Completion	BAFA	
Evaluation and background information	The evaluation is based on an interpretation of information available to the BMWi, BAFA, ZDH, the seven Chambers of Commerce involved, and – for the web page – the DIHK. There is much more information on the second phase of funding starting in 2016, provided by quarterly status reports. There is also more detailed data for use on the web page created for the second programme phase. In addition, energy savings was quantified by reviewing information on energy consumption in SME Initiative sectors that was collected in the survey on energy consumption in crafts, trade and services sector as well as information regarding indirect energy savings from various energy efficiency measures drawn from the evaluation of the SME Energy Advice programme.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	1	75
Final energy savings (in PJ)	0	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	37	5,000

Energy-efficient and Climate-smart Production Processes	
Summary	Support is given to measures to improve energy efficiency in commercial and industrial production processes. This includes in particular production processes and manufacturing process conversions, measures on efficient use of energy from production processes or production facilities. Funding is provided for up to 20% of the expenses that qualify. The requirements for funding is an investment of at least €50,000, specific energy conservation of at least 5% compared with the average consumption of the past 3 years, and annual savings of at least 100 kg of CO_2 for each €100 of investment cost.
Current status	In 2016, this programme was extended to 31 December 2017.
Type of instrument	Funding programme
Target group	Companies, contractors
Energy sources	Electricity, fuels

→

Energy-efficient and Climate-smart Production Processes		
Launch of the instrument	2013 (first audit in 2014)	
Completion	Project provider: Karlsruhe-Produktionstechnologie	
Evaluation and background information	Evaluation is conducted by Prognos AG on the basis of funding data of the project provider, additional information from applications and written surveys.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	3	5
Final energy savings (in PJ)	2	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	183	350

Support for market monitoring		
Summary	To ensure the reliability, effectiveness and efficiency of existing and new testing methods and standards, and ultimately, to strengthen the effectiveness and plausibility of product-related energy efficiency instruments used by the EU, the German Federal Institute for Materials Research and Testing (BAM) was assigned the task of testing this project. In addition, round robin tests were introduced to validate the testing methodologies or to detect any deficiencies. These tests verify whether norms used in market observations are suitable, that is reproducible, effective and efficient, and also provide a realistic picture of actual energy consumption. In addition, the methods are also reviewed regarding the possibility of simplification and optimisation with additional spot checks conducted by independent institutes that could reveal any deficiencies in the products being assessed.	
Current status	Round robin tests will be completed at the end of 2017, product testing by the 3rd quarter of 2018.	
Type of instrument	Market monitoring	
Target group	Equipment manufacturers, market monitoring authorities, households	
Energy sources	All	
Launch of the instrument	1 January 2016	
Completion	German Federal Institute for Materials Research and Testing (BAM)	
Evaluation and background information	The energy and greenhouse gases conserved by the project to improve market monitoring in 2016 cannot currently be assessed. The evaluation was launched only 2017.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	not specified (The effects will only be appreciable when the results from market monitoring are applied)	0.2
Final energy savings (in PJ)	not specified (The effects will only be appreciable when the results from market monitoring are applied)	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	not specified (The effects will only be appreciable when the results from market monitoring are applied)	14

National Top Runner Initiative (NTRI)		
Summary	The National Top-Runner Initiative (NTRI) is an effort spearheaded by the Federal Government to consolidate measures to accelerate the market penetration of energy-efficient products (top-runners) to increase product-related and multi-sector electricity efficiency. To achieve this goal, motivation and competence in electricity efficiency, product-related energy efficiency and rational use of energy along the value-added chain should be enhanced – from equipment manufacturers to trade and ending with consumers. The NTRI relates to all products regulated by EU directives on eco-design and the EU label. It was started in January 2016 and is active especially in the following areas: (a) consumer information (energy-efficient products, user behaviour), (b) trade as an efficiency multiplier, (c) impetus for developing future products, prototypes of the EU product database, and (d) stakeholder events.	
Current status	As of January 2017, a content and messages were disseminated in cooperation with business to target groups, and at the same time creating publicity for such products. Furthermore, innovation workshops and stakeholder events were drawn up that have been held since 2017.	
Type of instrument	Publicity work, cooperation with stakeholders	
Target group	Equipment manufacturers, trade, end consumers	
Energy sources	All	
Launch of the instrument	1 January 2016	
Completion	BAFA/BfEE	
Evaluation and background information	Savings effects will be assessed during the accompanying evaluation process conducted by IZT Institute for Future Studies and Technology Assessment.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	0.2	0.4
Final energy savings (in PJ)	not specified	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	not specified	21

EU Energy Label Directive		
Summary	In EU deliberations on the Energy Label Directive, Germany successfully campaigned for a clear and informative energy label. The Directive provides for a transition from A+++ ratings to a range of A to G, and describes the procedure and deadlines for the transition. The creation of an EU product database by 1 January 2019 should make it easier for consumers to compare efficiency of various products and for market surveillance authorities to monitor label requirements. The new Directive will also improve requirements for market surveillance and exchange of information between market surveillance authorities at the EU level.	
Current status	The first new product groups under the new Directive should become effective as of February 2020. This includes washing machines, dishwashers, refrigerating appliances, televisions, lamps and lighting. After that, additional product groups will be redefined and newly created.	
Type of instrument	Information	
Target group	Equipment manufacturers, market monitoring authorities, households	
Energy sources	All	
Launch of the instrument	The new Directive took effect August 2017.	
Completion	BMWi	
Evaluation and background information	Savings could be determined by an evaluation, and the initial data might be available at the end of 2019.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	not specified (Savings attributable to the new Directive will not be realised until after the first redefinition of a product group, about 2018–2019).	not specified
Final energy savings (in PJ)	not specified (Savings attributable to the new Directive will not be realised until after the first redefinition of a product group, about 2018–2019).	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	not specified (Savings attributable to the new Directive will not be realised until after the first redefinition of a product group, about 2018–2019).	not specified

STEP up! „STromEffizienzPotenziale nutzen“ (Utilize energy efficiency potential)	
Summary	The pilot phase of the funding programme STEP up! (Utilize energy efficiency potential) planned for completion by the end of 2018 was initiated in 2016. This programme is the first competitive bidding process for funding energy efficiency measures. It aims to activate the search function of the market for a cost-optimal means of saving energy. The programme was designed to be open to all technologies, participants and sectors. On the basis of the cost-benefit ratio (ratio of subsidized euros to saved kWh), all measures submitted in a financing round are compared and rated. Those measures that can provide the most economic cost-benefit ratios receive funding. The public invitations to tender are augmented with “closed invitations to tender” on rotating topics. The pilot phase should test the feasibility of competitive calls for bids for energy efficiency measures, as well as enhance and improve the programme (learning programme).
Current status	The first bidding round took place 1 June 2016–31 August 2016; the 2nd round 1 November 2016–31 January 2017; the 3rd round 1 March 2017–31 May 2017; and the 4th round 1 September 2017–30 November 2017. Two additional bidding rounds are planned for 2018.
Type of instrument	Funding programme (pilot phase)
Target group	Companies (and by way of joint projects, also private consumers)
Energy sources	Electricity; savings of other energy sources are allowed as of the 4th round during the closed invitations to tender; including heating is to be assessed by the end of 2018.
Launch of the instrument	1 June 2016

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STEP up! „STromEffizienzPotenziale nutzen“ (Utilize energy efficiency potential)		
Completion	Project sponsors VDI/VDE-IT GmbH	
Evaluation and background information	Evaluation is conducted by Prognos AG and the ifeu Institut on the basis of funding data of the project provider, additional information from applications and written surveys.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	0.10	not specified
Final energy savings (in PJ)	0.04	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	6	not specified

Energy Savings Meter pilot programme	
Summary	The Energy Savings Meters pilot programme provides funding for digital platforms for the energy transition. Any company may participate that tests innovative digital systems and accompanying business models that save energy and can be developed as a scalable business model for end customers. A prerequisite is installation of digital systems such as Smart Home, Smart Meter, Smart Building, and measurement and control technology that help customers to conserve energy. Half of project funding is contingent on proof of energy savings at the end customer using an “energy savings metre”. Pilot projects for saving electricity, gas, heat and cooling may be funded with up to €1 million of project funds. The main idea is to individualize actual energy savings potential on the basis of continual measurement of individual energy consumption (“assistants”) and use this information to create value-added services for energy efficiency on digital platforms. In addition, this funding program is the first effort at creating the methodology requirements for quantifying actual energy savings that are always verifiable and can be used in comparisons. This should help quantify the extent of rebound effects, design countermeasures and implement value-added services such as demand-side management for sector coupling. Eligible for funding is the development of digital platforms and energy services that encourage customers to conserve energy, not however the implementation of the savings measure itself; this should be supplied by the market.
Current status	• Funding: funds were increased to €62 million during the project period. • Development of methods: About one dozen issue-specific workshops with 10-60 participants and about one workshop each quarter with 50-100 participating companies in Berlin and Eschborn. Working out basic methodology concepts for defining scalable, universal measurement methods using digital platforms and to introduce them to various applications to make them comparable, and thereby manageable and “contractable”. Continual verification, further development and standardisation of measuring methods. • Applications: Up to now, 38 applications, of which 21 were granted • Next milestones: As of 2018, monthly anonymized and aggregated energy conservation amounts have been determined. As a way to improve methods, tests are conducted to determine the savings actually achieved by energy measures and whether the “conserved kWh” as shown on the energy saving metres could be consolidated and made available to commercial investors (scale-up) – Energy Saving Metres as an Operating System for Efficiency 4.0.
Type of instrument	Innovation programme for introducing digital energy conservation assistants and business models
Target group	Start-ups, energy industry, contractors, businesses that conduct energy-saving projects at the end customer
Energy sources	Line- and pipe-sourced energy (electricity, gas, heating, cooling)
Launch of the instrument	May 2016
Completion	BAFA

→

Energy Savings Meter pilot programme		
Evaluation and background information	Evaluation by ifeu in the context of the parallel project "Evaluation and Monitoring of Financing for the Programme Energy Saving Metre", Project coordinator: co2online, additional partner: Ökotec. This is based on BAFA data on the funding process. The programme was initiated in May of 2016; the innovative funding system for line- and pipe-sourced components for actual energy savings requires sufficient time for applications and evaluation. This explains the low number of applications approved in 2016 compared to 2017. More detailed results in the form of initial metre data are expected as of 2018.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	0	not specified
Final energy savings (in PJ)	0	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	0	not specified

Funding guidelines for energy management systems		
Summary	The goal of the funding guidelines for energy management systems is to encourage the implementation of energy management systems to ISO 50001 in industry. The main idea is that only by identifying energy utilization is it possible to identify effective energy saving measures and implement them. The ISO 50001 norm follows the plan-do-act-check cycle and provides for continual improvement of energy performance of the company. It has been shown that companies operating an energy management system to ISO 50001 implement measures that quickly pay for themselves. It is assumed that companies with a reporting system can save up to 10% of their primary energy consumption, depending on the sector.	
Current status	The current guideline has been in effect since 1 January 2017. This includes small changes for companies qualifying for funding and for the measures being funded.	
Type of instrument	Funding programme	
Target group	Companies	
Energy sources	Fuels and electricity	
Launch of the instrument	July 2013	
Completion	BAFA	
Evaluation and background information	Evaluation of the programme in 2017 by Fraunhofer ISI on behalf of BMWi as well as in the context of the evaluation of the Energy Efficiency Fund (see interim report 2017 for BMWi, section on energy management systems)	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	1	not specified
Final energy savings (in PJ)	1	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	67	83

Monitoring of central measures for funding energy savings measures is outlined in Chapter 6.4.

6 Buildings

Where do we stand?

Primary energy consumption in buildings (see Chapter 6.2 for a definition) went down in 2016, by 3.2%. Benchmarked against the baseline year, 2008, primary energy consumption was down 18.3%.

Conversely, final energy consumption in buildings went up by 4.3% compared with 2015. Compared with 2008, consumption was down by 6.3%. Since 2008, final energy consumption related to buildings has declined by an average of around 0.8% annually. In order to achieve the target of 20% reduction by 2020, consumption would have to go down five times as fast in the years remaining to 2020. Such a steep drop is improbable. There is a great need take action to achieve the savings target as quickly as possible.

The share of renewables in heat consumption stood at 13.2% in 2015, which is already very close to the 2020 target of 14%.

Numerous programs for the buildings sector were expanded in 2016 – some under the Energy Efficiency Strategy for Buildings (ESG) – and new programmes were initiated. Additional successful measures of the Federal Government (see Chapter 16) include the introduction to the market of the "Effizienzhaus-Plus" building standard.

This standard takes both primary and final energy consumption into account and promotes the use of renewable energy.

What is new?

The coalition agreement between the CDU, CSU and SPD emphasizes the fact that to accelerate the energy transition in the heating sector, both energy efficiency and the use of renewables in the buildings area must be encouraged. The basic tenets of profitability, openness to technology and simplification apply to such efforts. The coalition agreement also provides for complete implementation of the 2050 Climate Action Plan.

	2016	2020	2030	2040	2050
Efficiency and consumption					
Primary energy consumption in buildings (compared with 2008)	-18.3%	→	→	→	-80%
Heat consumption in buildings (compared with 2008)	-6.3%	-20%			
Renewable energy					
Share of heat consumption	13.2%	14%			

6.1 Energy consumption in buildings

The buildings sector plays a central role in the energy transition. The share of building-related final energy consumption for 2016 was about 35.3% in total. Private households accounted for the majority of this energy consumption, followed by the trade, commerce and services (TCS) sector, and industry (see Diagram 6.1).

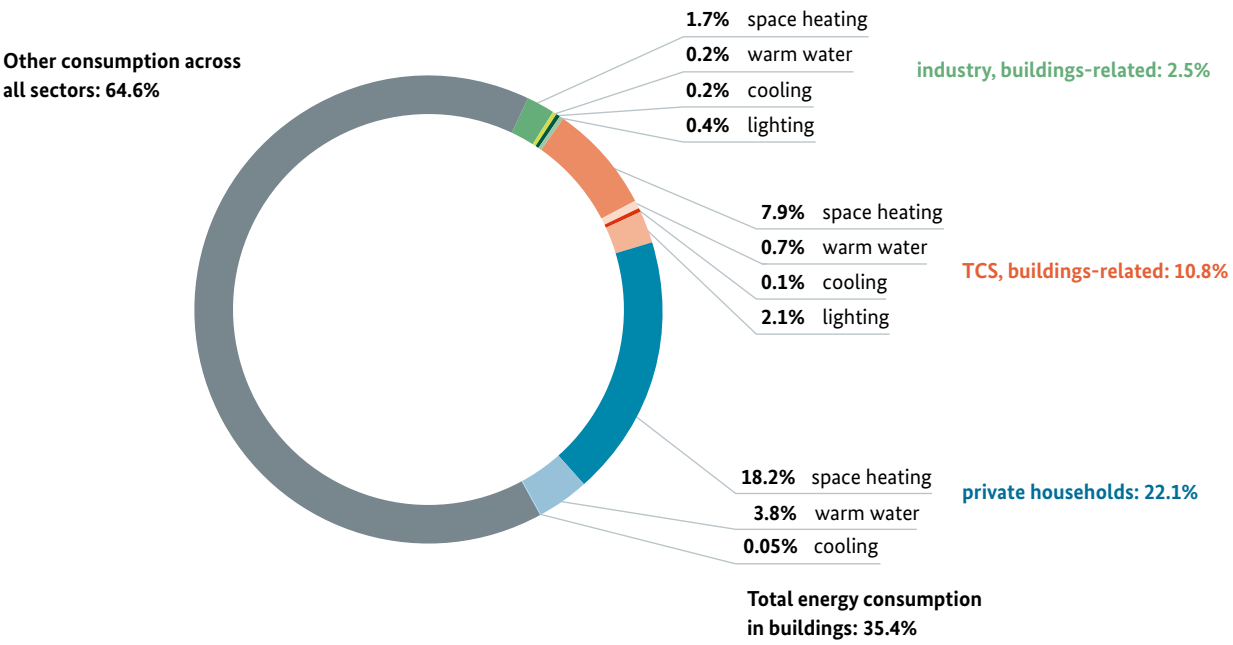
Final energy consumption in buildings, also referred to as heating energy demand, rose in 2016, Building-specific final energy consumption for heat (heating energy demand) comprises consumption data for space heating, space cooling and warm water supply. In addition, the power consumption of (permanent) lighting systems in non-residential buildings is also included, reaching 3,235 PJ in 2016, an increase of 4.3% over 2015. This increase was largely due to the relatively cold temperatures compared to the previous year, leading to increased heating demand.

Even if the heating demand in the previous three years decreased, it has increased by 6.3% overall since 2008. This means that heating energy demand fell annually by around 0.8% on average during this period. To reach the target of cutting heating energy demand by 20% by 2020 compared to the 2008 baseline, heating demand would have to drop on average 3.9% annually between 2016 and 2020 – five times faster than previously. Such a steep drop is improbable. Much work must be done to reach the target as quickly as possible. Key measures for the reduction of energy consumption have been introduced with the adoption of the National Action Plan on Energy Efficiency (NAPE) and the development of the Efficiency Strategy for Buildings (see Chapter 6.4).

The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of cutting final energy consumption in the buildings sector by 20% compared with 2008 will be missed. The study expects that the reduction will be about -12.5% by 2020 (within a range of -11.5% to -15.8%, see Diagram 6.3). This takes the effects of measures taken under the Target Architecture Study into account.

Energy efficiency in buildings declined in 2016 compared to 2015. Final energy consumption of private households increased more strongly than the amount of residential space. The ratio of these two values to one another reflects the level of energy efficiency in the buildings sector: specific final energy consumption for space heating in private households increased by 4.3% on the previous year. After adjusting for weather effects, this increase is lower, at 2.8%.

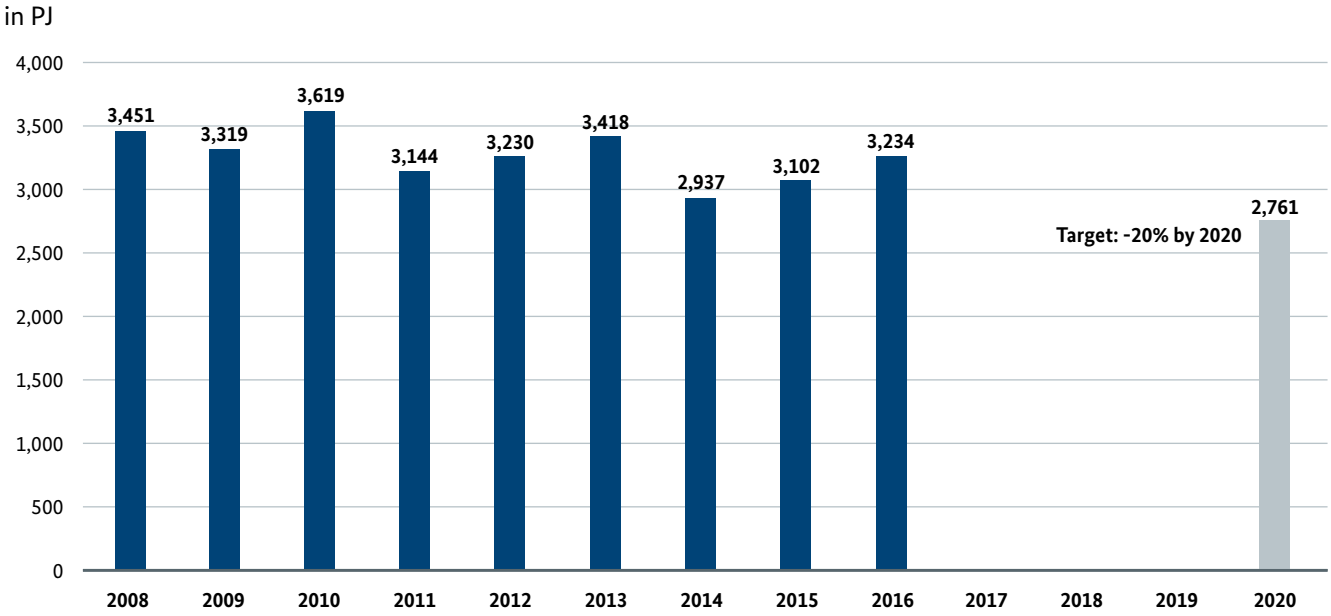
Diagram 6.1: Share of final energy consumption in buildings in total final energy consumption in 2016



Source: Working Group on Energy Balances, 11/2017

Diagram 6.2: Meeting the target for heating energy demand

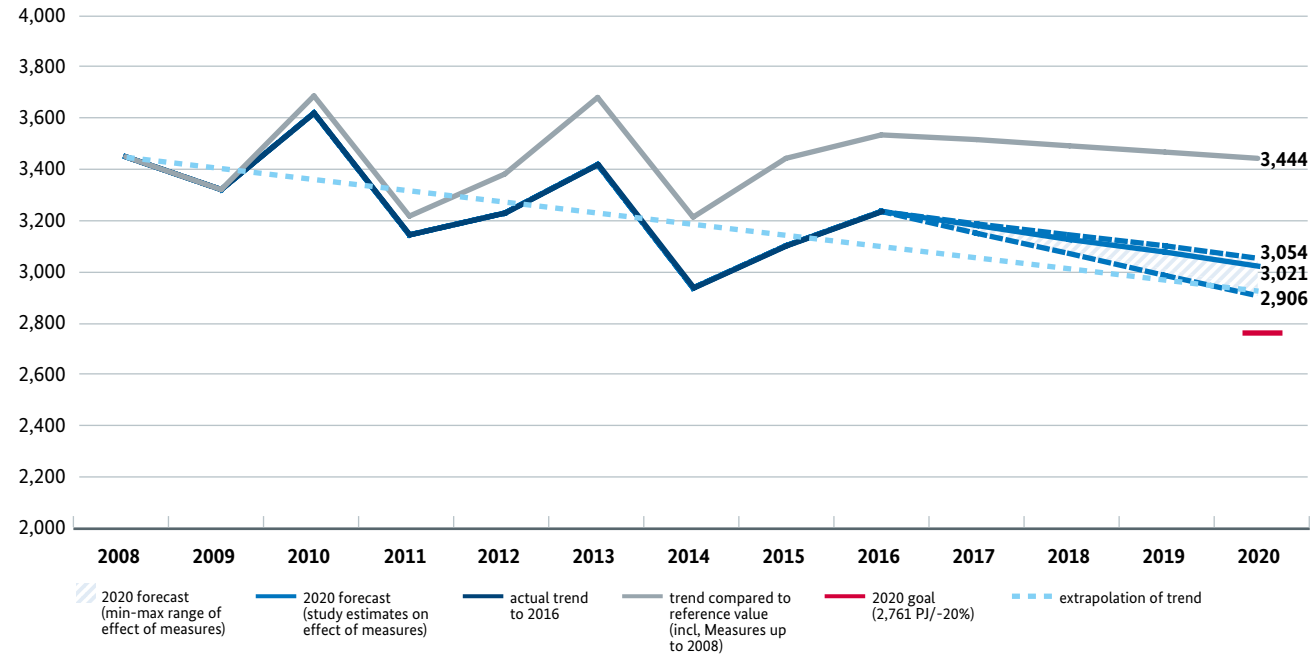
2020 target	20% reduction in final energy consumption for heating (compared with 2008)
Status in 2016	-6.3%



Source: Working Group on Energy Balances, November 2017

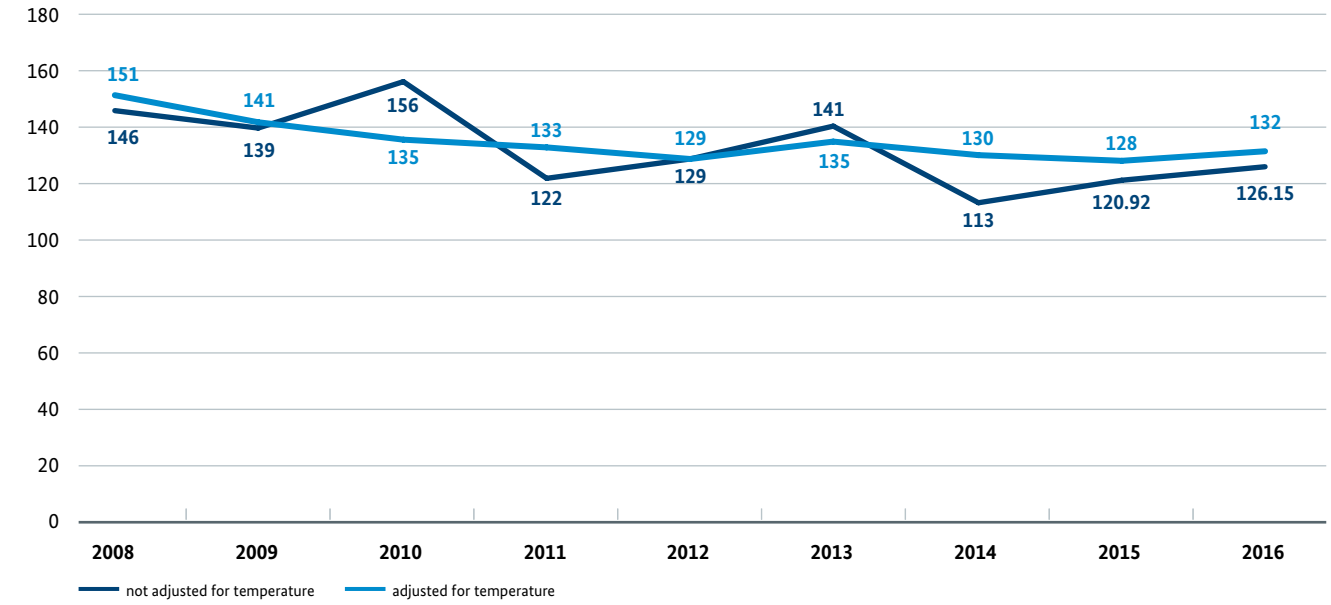
Trend	●●●○○
Measures	National Action Plan on Energy Efficiency, Efficiency Strategy for Buildings and Climate Action Programme

Diagram 6.3: Reduction of final energy consumption according to the Target Architecture Study



Source: Prognos, Fraunhofer ISI, DLR (2018)

Diagram 6.4: Development of specific final energy consumption for the generation of space heating in private households
in kWh/m²



Source: Working Group on Energy Balances, StBA 11/2017

Compared with 2008, residential buildings use energy much more efficiently today. In 2016, a median value of 13.5% less energy was used for heating per square metre than in 2008 (see Diagram 6.4). This means that, on average, energy in the residential buildings sector has been used more and more efficiently, resulting in an overall decline in heating energy demand despite increasing residential space. After adjusting for temperature, final energy consumption for space heating among private households in 2016 was 12.9% lower than in 2008.

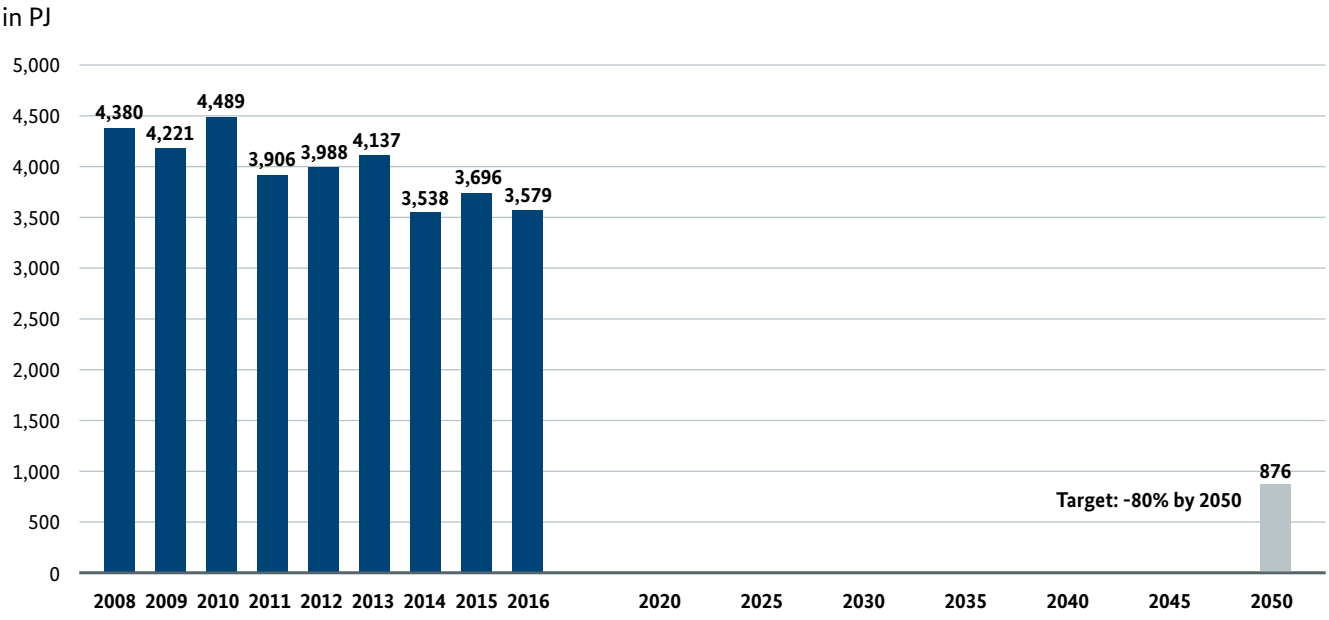
6.2 Primary energy consumption

Primary energy consumption of buildings was 3.2% lower in 2016 than in the previous year. In addition to the provision of heating, cooling, warm water, and also lighting in the case of non-residential buildings, the primary energy consumption indicator also factors in the non-renewable effort for the production, conversion and transportation/distribution of the individual energy sources. Primary energy consumption does not encompass renewable energy sources, however. It can therefore be reduced both by energy efficiency improvements and by increasing the share of renewables to cover heating energy demand. In 2016, primary energy consumption stood at 3,597 PJ compared with 3,696 PJ in the previous year.

Primary energy consumption has already decreased by over 18% since 2008. This is equivalent to an average annual reduction of 2.5%. This is a clear indication that Germany is on the right track to reducing primary energy consumption (Diagram 6.5). As the primary energy consumption goal is set far into the future (80% reduction by 2050 compared with 2008 levels), it does not make sense to extrapolate the value on a linear basis to estimate the level of progress

Diagram 6.5: Meeting the target for primary energy consumption

2050 target	Reduction of primary energy consumption by 80% (compared with 2008)
Status in 2016	-18.3%



Source: BMWi on the basis of the Working Group on Energy Balances 11/2017

Trend	No trend information available given the long goal horizon to 2050
Measures	National Action Plan on Energy Efficiency, Efficiency Strategy for Buildings and Climate Action Programme

towards the goal. However, the forecast in the reference scenario used in the Efficiency Strategy for Buildings suggests that - based on existing instruments (as at 2013) - primary energy consumption could drop by around 60% by 2050 compared with 2008 levels.

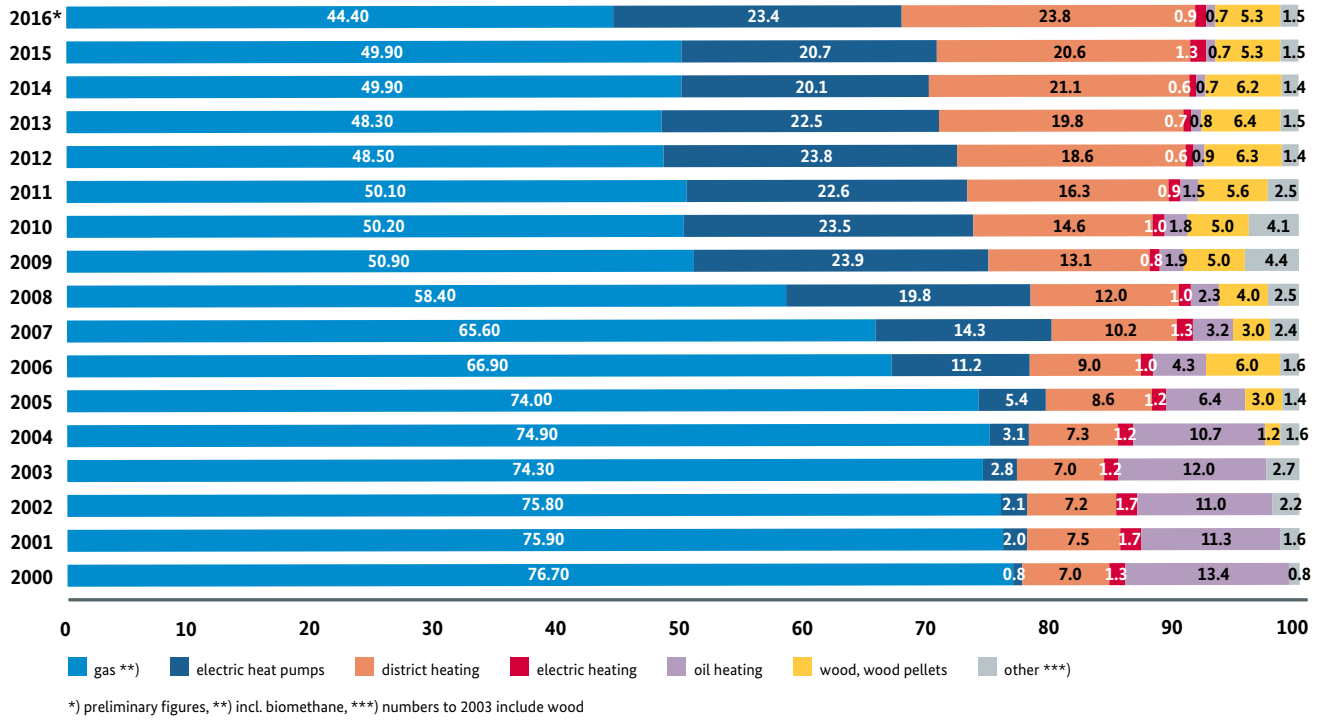
6.3 Modernisation and investment in the buildings sector

In 2016 building permits were issued for renovating or new construction for a total of 365,000 residential units and around 270,000 units were completed. This corresponds to an increase of almost 20% in permits and 12% in finished units. New construction accounted for about 317,000 units, e.g. about 86% of the 365,000 residential units. At the same time, in 2016 around 160,000 residential units received financial support through the KfW programme Energy Efficient Construction as part of the CO_2 building refurbishing programme. That is, about one-half of the new residential units receiving permits in 2016 were funded by the Federal Government, and accordingly, built to a higher energy efficiency standard than the Energy Saving Ordinance requires. With the help of the Energy-efficient Refurbishing programme, the energy efficiency of around 276,000 residential units in total was increased in 2016. Energy-efficient construction opens up the potential for profitable solutions. This also enhances the competitiveness of the construction sector.

With regard to renewables (RES) for heat generation, the installation of roughly 67,800 renewable energy heating systems - primarily in residential buildings - was promoted in 2016 under the Market Incentive Programme for Renewable Energy in the Heating Market (MAP). This corresponds to an increase of almost 80% over the previous year. The technologies deployed comprised solar thermal, biomass and heat pumps. The grants paid out in 2016 amounted to €182.3 million in total. This is almost twice as much as in the previous year. The investment volume of these measures amounted to around €937 million.

New construction is increasingly equipped with climate-friendly heating systems. For example, installation of oil heating, a greenhouse-gas polluter, has gone down since 2000 from 13.4% to 0.7% in 2016. And, heat pumps are on the rise in new construction, from 0.8% in 2000 to 23.4% in 2016 (see Diagram 6.6 and Chapter 13.1).

Diagram 6.6: Heating systems in new residential units from 2000 to 2016
in %



*) preliminary figures, **) incl. biomethane, ***) numbers to 2003 include wood

Source: BDEW, 02/2017

Transparency and participation: anyone can get involved in the heating transition.

The Energy Transition Platform for Buildings was set up in 2014, and offers the property sector, trade, industry and consumers and the public sector the possibility for dialog on the many opportunities in the building sector and existing challenges. The 7th meeting of the platform took place in late 2017. A consumer-friendly overview of all efficiency promotion programmes of the German government in the building sector can be found at www.deutschland-machts-effizient.de. The voluminous information on energy efficiency and energy conservation is focussed on building-related topics such as energy technology in construction and refurbishing.

The Effizienzhaus Plus initiative, started in 2011, provides all target groups with information that is practical and understandable regarding energy efficient, sustainable and future-oriented construction. There are instructive suggestions on how to rethink construction for the future and to implement climate and energy targets in the buildings sector. For more information, see www.forschungsinitiative.de/effizienzhaus-plus.de/.

The government Information and Competency Centre for Future-oriented Construction has been providing information to the public since 2017 on specific solutions for environmentally-conscious construction in the framework of the former Effizienzhaus Plus research programme. With this platform the Federal Government is providing any interested persons or entities a form for a dialog on this topic. Additional information can be found at www.bauen-der-zukunft.de.

6.4 Efficiency Strategy for Buildings and National Action Plan on Energy Efficiency

Final energy consumption needs to be reduced and the share of renewables in the heating sector increased if Germany is to meet the Federal Government's goals in the buildings sector by Year 2050. The 14% target for the share of renewables in total heat consumption will soon be reached. The progress made in this area is discussed in detail in Chapter 4.3. In order to continue to lower energy consumption in buildings, the National Action Plan on Energy Efficiency (NAPE) has initiated additional immediate measures and farther-reaching work processes for improved energy efficiency in the buildings sector, as well as in other sectors. The Efficiency Strategy for Buildings builds on this. The Energy Conservation Act together with the Energy Conservation Ordinance (EnEV) and the Renewable Energies Heat Act provide an important contribution to the targets in the buildings sector.

The Efficiency Strategy for Buildings is a strategy for the energy transition in the buildings sector. Containing both new measures and proposals for the development of existing measures, this strategy shows how the goal of a virtually climate-neutral building stock by 2050 can be achieved by combining greater energy efficiency with the increased use of renewable energy. The current set of instruments already reaches many building owners and encourages them to invest in energy efficient construction and renovation projects as well as investment in their buildings. Implementation of the Efficiency Strategy for Buildings commenced in 2016. Several measures are currently in the initial phases and must be enhanced and expanded. Comprehensive information campaigns such as 'Germany makes it efficient' can assist in this effort.

Numerous programs for the buildings sector were expanded in 2016 – some under the Energy Efficiency Strategy for Buildings (ESG) – and new measures were initiated. For example, the Energy Efficiency Incentive Programme (APEE) includes a 'Heating and Cooling Package' funding component, a new subsidy for efficient combination solutions. Also new is the 'Programme for Promotion of Heating Optimisation Using High-Efficiency Pumps and Hydraulic Balancing' (HZO) aimed at low-threshold, smaller efficiency measures – a logical addition to the existing funding landscape that provide incentive to apply additional efficiency measures. Another funding initiative introduced in April 2016 with the title 'Energy-efficient Buildings 2050 – Innovative Projects for a Virtually Climate-neutral Building Stock in 2050' provides assistance and support for innovative solutions and technologies, with the aim to broaden their impact. To use the benefits of digitisation in the area of energy efficiency, the Federal Ministry for Economic Affairs and Energy started the Energy Savings Metres pilot programme in May 2016. To satisfy the high demand and avoid a discontinuation of this program, the budget has already been doubled. In addition, the Heating Networks 4.0 funding programme was initiated in July 2017 as a systematic assistance programme for the heating infrastructure, which encompasses not only stand-alone technologies and components, but also entire systems. The ESG was also incorporated into the Climate Friendly Building and Housing Strategy, part of the Federal Government's 2050 Climate Action Plan.

The CO_2 Building Modernisation Programme, the Market Incentive Programme for Renewable Energies (MAP) and the Energy Efficiency Incentive Programme (APEE) were very successful in 2016. These programmes were extensively utilised in 2016. The KfW programmes for energy-efficient construction and retrofitting – part of CO_2 Building Modernisation Programme – are still in high demand. In comparison to the previous year the residential units receiving funding climbed to about 18% and the amount of funding to about 20%. The funding programmes under NAPE were also well utilized. The Market Incentive Programme for Renewable Energies was met with increasingly high demand both in the area of funding innovation related to highly efficient heat pumps as well as for profit-oriented funding of solar thermal installations. The APEE – set up as an alternative to tax incentives for energy efficient refurbishment of buildings, has been in high demand since its inception in 2016. The APEE promotes replacement of inefficient heating systems ("heating package") installation of ventilation systems ("ventilation package") and innovative fuel cell heating systems for new construction and existing buildings.

Energy consulting programmes are important components of the Federal energy efficiency and climate policies. Professional energy consultation can unleash potential for efficiency and savings, as well as clarify the costs of implementation and how to finance such measures or apply for funding. At the same time, energy consulting empowers energy consumers to develop their own knowledge and helps them avoid imprudent investments. It often provides impetus for ambitious efficiency measures, thereby contributing indirectly to significant energy savings. To improve energy consultation, a major component of the Energy Efficiency Strategy for Buildings called the Individual Renovation Roadmap was started in 2017 for residential buildings. This Roadmap provides consultation customers with a personalized step-by-step refurbishing plan.

Monitoring of central measures for funding energy savings in the buildings sector

CO_2-Building Modernisation Programme: residential buildings		
Summary	This programme sponsors energy-saving refurbishing projects for residential buildings with low-interest loans, sometimes combined with redemption subsidies or subsidies. Funding is provided both for individual measures (e.g. heating, ventilation, insulation) and combinations (heating and ventilation package), as well as complete packages for achieving KfW Efficiency House standards (refurbishing and new construction). Standards for primary energy consumption of the building and overall insulation of the building exterior must be complied with.	
Current status	Introduction on 1 April 2016 of a new funding standard, "Efficiency House 40 Plus" in the residential building sector as well as raising the cap on funding from €50,000 to €100,000.	
Type of instrument	Funding programme	
Target group	Owners, first buyers, and builders of residential buildings and condominiums	
Energy sources	Natural gas, heating oil, coal, liquefied gas, biomass, electricity and district heating	
Launch of the instrument	2006	
Completion	KfW	
Evaluation and background information	Energy savings from NAPE comprise the entire programme starting in 2006, including additional funding in 2014 as part of NAPE. The amount of primary energy saved attributable to the measures carried out between 2006–2010 was determined ex post facto on the basis of assessments of carbon savings and the ratio of CO_2 to final energy savings in the 2011–2016 period. The basis for these figures is the report "Monitoring of the KfW Programmes Energy-efficient Retrofitting and Energy-efficient Construction, 2016, IWU/IFAM, 16 February 2018". The methods used to determine the energy balance are based on energy demand estimates that have not yet been compared with actual consumption. A procedure for refining these figures is currently being developed. A new bid for evaluation is planned for 2018, during which the target indicators should also be redefined.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	101	not specified
Final energy savings (in PJ)	77	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	7,683	not specified

CO_2-Building Modernisation Programme: non-residential buildings	
Summary	This programme sponsors energy-saving refurbishing projects for non-residential buildings with low-interest loans, sometimes combined with redemption subsidies or subsidies. Funding is provided both for individual measures (e.g. heating, ventilation, insulation) and combinations (heating and ventilation package), as well as complete packages for achieving KfW Efficiency House standards (refurbishing and new construction). Standards for primary energy consumption of the building and overall insulation of the building exterior must be complied with.
Current status	In 2016 there was no change in the main funding requirements.
Type of instrument	Funding programme
Target group	The programmes are aimed at owners, first buyers and builders of non-residential buildings and condominiums.
Energy sources	Natural gas, heating oil, coal, liquified gas, biomass, electricity and district heating
Launch of the instrument	2007
Completion	KfW
Evaluation and background information	Funding programmes are continually evaluated, most recently in 2015 for the period 2011–2014 by the IWU and Fraunhofer.

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CO_2-Building Modernisation Programme: non-residential buildings		
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	not specified	not specified
Final energy savings (in PJ)	5	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	466	not specified

Energy Efficiency Incentive Programme (APEE)		
Summary	This programme promotes replacement of heating units for optimizing the total heating system (fossil and renewable), installation of ventilation systems in combination with an additional improvement to the outside building surface (e.g. windows) and introducing fuel cell heating systems. The program was integrated into the CO_2-Building Modernisation Programme and the Market Incentive Programme.	
Current status	This programme was launched on 1 January 2016, starting with the Heating Package and Ventilation Package funding components. The Fuel Cell funding component was launched on 1 August 2016.	
Type of instrument	Funding programme	
Target group	Residential building and condominium owners, energy service providers (contractors)	
Energy sources	Natural gas, heating oil, coal, liquified gas, biomass, electricity and district heating	
Launch of the instrument	2016	
Completion	KfW and BAFA	
Evaluation and background information	The basis is the report “Monitoring of the KfW Programmes Energy-efficient Retrofitting and Energy-efficient Construction, 2016, IWU/IFAM, 16 February 2018”. The methods used to determine the energy balance are based on energy demand estimates that have not yet been compared with actual consumption. A procedure for refining these figures is currently being developed. A new bid for evaluation is planned for 2018, during which the target indicators should also be redefined. Note: The table indicates the energy savings and greenhouse gas reductions for the funded measures. However, the total effects of the funding programme could not be quantified. This is not a comprehensive quantification of the effects of the funding programme.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	2	not specified
Final energy savings (in PJ)	1	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	142	not specified

National Efficiency Label for old heating systems	
Summary	The National Efficiency Label for old heating systems is intended to inform consumers of the efficiency level of their old heating systems and motivate them to replace inefficient heaters. The Label is issued by a district chimney sweeper, a heating specialist or energy advisor who personally inspects the heating system, explains the Label and provides the consumer with a brochure with information on consulting and promotions. It is expected that the German heating label will increase the rate of replacement by about 20%, to 3.7% annually.
Current status	The Label may be issued by heating specialists and other specialists as of 1 January 2016. As of 1 January 2017, district chimney sweepers are required to affix the Label to old heating systems in a specific sequence. Based on the evaluators’ first progress report, since chimney sweepers have become involved in 2017 targets will most likely be achieved.

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National Efficiency Label for old heating systems		
Type of instrument	Information	
Target group	Households, small trade, commerce and service businesses	
Energy sources	Gas and oil	
Launch of the instrument	2016	
Completion	BAFA	
Evaluation and background information	Evaluation is carried out by IZT and the Oeko Institute as part of the NAPE evaluation for 2016, and a semiannual internal report. Methodology for estimating the savings: estimates are based on the number of Label packages requested and evaluation of the data on Label orders, online requests of households voluntarily interested and those required to have a Label, as well as the information gathered on replacement rates and type of replacement. From now on, the results of a survey of owners will also be included.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	0.006–0.019	4.6–13.9
Final energy savings (in PJ)	0.005–0.016	0.3–2
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	0.42–1.33	0.3–1

Promotion of heating optimisation using high-efficiency pumps and hydraulic balancing		
Short description	The goal of the heating optimisation programme is to replace up to two million inefficient heating and warm water circulation pumps annually with highly efficient pumps, and to optimize operation of up to 200,000 existing heating systems with what is known as hydraulic balancing. In order to exploit this potential, the heating optimisation programme provides an incentive of up to 30% subsidy of net investment costs for optimising existing heating systems.	
Current status	The initial phase runs to the end of 2016, with monthly increases in applications.	
Type of instrument	Funding programme	
Target group	Private individuals, companies, municipalities, cooperatives and not-for-profit organizations	
Energy sources	Gas, oil, electricity	
Launch of the instrument	1 August 2016	
Implementation	BAFA	
Evaluation and background information	Annual evaluation of the programme started in June 2017. The first reliable results are expected for 2018.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	0.03	not specified
Final energy savings (in PJ)	0.02	not specified
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	2	1,800
Programmes financed (number per year)	20,989 (08/16–12/16)	Replacing 2 million inefficient pumps and completing 200,000 hydraulic balancing procedures annually

Market Incentive Programme on Promoting Measures for Use of Renewable Energy in the Heating Market(MAP)		
Short description	MAP sponsors investments in the use of renewable energy, mostly in existing buildings. MAP comprises two parts: 1) investment grants from BAFA for small solar thermal power plants and biomass plants as well as efficient heat pumps and 2) loan repayment subsidies in combination with KfW loans from the KfW Renewable Energy – Premium or Renewable Energy - Deep Geothermal Energy programmes for large solar plants, biomass heating plants, specific efficient heat pumps, biogas pipelines, deep geothermal plants, municipal heating networks for heat from renewable energy (supplement to subsidies under the Combined Heat and Power Act), large heat accumulators for heat from renewable energy.	
Current status	When the new funding guidelines became effective on 1 April 2015, funding for MAP was secured for 2015–2019 with a volume of over €300 million annually. MAP is aimed at continually encouraging market development in the area of renewable energy for heat and cooling purposes and spurring innovation.	
Type of instrument	Funding programme	
Target group	Private households, companies, municipalities	
Energy sources	All	
Launch of the instrument	2000	
Completion	BAFA and KfW	
Evaluation and background information	MAP is continually evaluated and scientifically improved in order to take account of current technological advances and market developments. Data comes from a preliminary version of the 2016 evaluation report.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	1.4	5
Final energy savings (in PJ)	1.5	5
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	792	2,373

Energy-efficient Buildings 2050 – Innovative Projects for a Virtually Climate-Neutral Building Stock in 2050		
Short description	The goal of the Energy-efficient Buildings 2050 funding initiative is to showcase ambitious plans for almost completely climate-neutral buildings and urban quarters construction, and thereby encourage widespread acceptance. The main thrust is that the projects should address the challenges involved in achieving a largely climate neutral building stock, to pick up current research findings and innovation and to provide models for broad acceptance.	
Current status	In October 2017 the funding requirements were revised and republished. Funded projects now may run over up to five years, and funding requirements were adapted slightly to make the transformation projects in particular more attractive.	
Type of instrument	Funding programme	
Target group	Consortiums comprised of companies and research institutions	
Energy sources	All	
Launch of the instrument	2016	
Implementation	Various project sponsors	
Evaluation and background information	Given the character of the measure (sponsoring flagship projects, partially with research and development elements), direct energy savings are not the primary goal of EnEff.Gebäude.2050, and as a result, are comparatively small. Instead, the goal is finding a multiplicator effect for the concepts, technologies and solutions that are developed, and correspondingly, overcoming hurdles in implementing the energy transition in the buildings sector. Research into the aggregate effects of the funding initiative, including the planned flagship and publicity effects is part of a planned accompanying research project. Initial estimates of effects will not be available until the end of 2018, whereby there is no indication of whether a quantitative projection of total effects is possible.	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	0 (see above)	0 (see above)
Final energy savings (in PJ)	0 (see above)	0 (see above)
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	0 (see above)	0 (see above)

Energy consulting		
Short description	Energy consultation for consumer centres, municipalities, small and medium-sized businesses, and for residential buildings (on-site consultation, personalized renovation planning)	
Current status	Stricter requirements for consultants went into effect 1 January 2016. The quality of consultation reporting has been continually improved. In 2016 and 2017 a personalised renovation plan was developed for owners of residential buildings, and was integrated into energy consultation for residential buildings in July 2017. The pool of energy consultants authorised to submit applications for the residential building consultation and SME consultation programmes was expanded to include tradesmen and chimney sweeps, among others. Energy consultation continues to be balanced and high quality. Professional information on energy consultants must be published (Energy Efficiency List of Experts for Federal Funding). Energy consultation provided by consumer centres is not included in this new regulation. To bring energy consultation and energy check-ups closer to private consumers, the project began receiving funding in summer of 2016 for regional managers, co-funded by the Federation of German Consumer Organisations (vzbv) and consumer centres. The guideline titled Energy Consultation for Non-residential buildings in Municipalities and Nonprofit organisations entered into force on 1 January 2016.	
Type of instrument	Funding programmes	
Target group	Private individuals, tenants and owners, companies, municipalities and not-for-profit organisations	
Energy sources	Electricity, heating	
Launch of the instrument	Already in use	
Implementation	BAFA	
Evaluation and background information	Evaluation of the consultation programmes takes place at least every three years. Evaluation of the energy savings consultation and energy check-ups conducted by consumer centres (2017), energy consultation for SMEs and for non-residential buildings in municipalities and non-profit organisations (currently being conducted), energy consultation for residential buildings (2014, call for bids planned for 2018).	
Monitoring indicators	2016	Target indicator of the instrument for 2020
Primary energy savings (in PJ)	5	6
Final energy savings (in PJ)	5	4
CO_2 savings (in kilo tonnes of CO_2 equivalent per year)	325	250

7 Transport

Where do we stand?

Having risen 4.2% from 2005 levels, the development of final energy consumption in the transport sector continued to run counter to the goals of the Energy Concept. It is expected that the 2020 Goal (reduction by 10%) will not be reached until around 2030 under the present circumstances. Considerable additional efforts will be required to turn this trend around as soon as possible.

This includes the greatest possible electrification of vehicle drives. With the exception of rail transport, Germany is still at the start of this process. Nonetheless, the number of vehicles with alternative drives is steadily increasing. Here, the focus is on the faster expansion of the necessary infrastructure.

Another option for reducing final energy consumption is to switch transport from road to rail, which is more environmentally friendly. If this is to materialise, it will require continued high-level investment in the rail infrastructure, the introduction of innovative technologies in rail transport and new logistics solutions. A federal research programme for rail transport is currently underway. The basis is the research overview on rail transport research currently being prepared. Ultimately, an automated and digitised rail transport system should be the outcome.

What is new?

The coalition agreement between the CDU, CSU and SPD includes an agreement that the measures set out in the Rail Freight Masterplan will be continually implemented to establish rail freight in the long term. One important measure could be to reduce track access charges with additional federal subsidies.

With the eco-bonus, the amendments to the Charging Station Ordinance and other measures to support the creation of a nationwide charging infrastructure, the Federal Government is continuing its work to bring electric mobility to the mass market.

The Federal Government wants to create sustainable and climate-friendly mobility. The goal is to avoid driving restrictions, which are now legal in municipalities under the decision of the Federal Administrative Court issued in February 2018. At the same time, health hazards should be minimised. To counteract nitric oxide (NO_x) emissions in inner cities that continually exceed the thresholds, the Federal Government launched a dialog in 2017 with the automotive industry, the Länder and municipalities under a Clean Air Immediate Action Programme for 2017–2020, that introduces numerous measures for substantially accelerating by 2020 the trend already underway to improve air quality regarding nitric oxide. Here, too, it is important to improve the attractiveness of city and regional rail traffic. In particular, commuter traffic could be made more environmentally friendly.

Research initiatives also address the energy transition in the transport sector by using energy generated from renewable sources and by means of sector coupling (as with the Efficiency House Plus initiative). Other initiatives deal with LNG and electric drivetrain technology for ships and heavy goods vehicle traffic.

	2016	2020	2030	2040	2050
Efficiency and consumption					
Final energy consumption in the transport sector (compared with 2005)	4.2%	-10% →			-40%

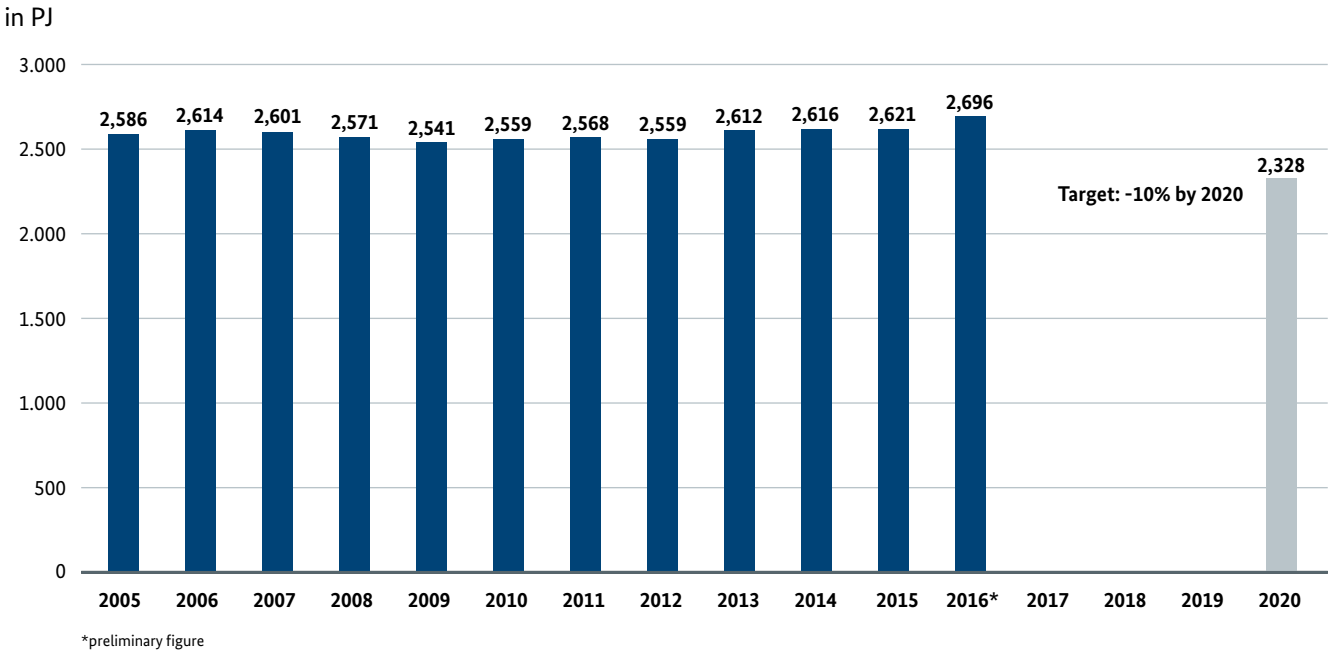
7.1 Energy consumption in the transport sector

Final energy consumption in the transport sector increased in 2016. Taking all modes of transport together, final energy consumption in the transport sector stood at 2696 PJ in 2016, up 2.9% on the previous year (see Diagram 7.1). The transport sector therefore accounted for roughly 29% of total final energy consumption in Germany.

As Table 7.1 shows, energy consumption for road and air transport (international and domestic) has increased – both on the previous year and on the baseline year, 2005. In the rail sector and in inland water transport, energy consumption has decreased compared with 2015. On account of a revision of rail sector data, it is not possible to compare energy consumption directly with 2005 values. However, it can be assumed that energy consumption has decreased.

Diagram 7.1: Meeting the target for final energy consumption in the transport sector

2020 target	10% reduction in final energy consumption (compared with 2005)
Status in 2016	+4.2%



Source: Working Group on Energy Balances, September 2017

Trend	● ○ ○ ○ ○
Measures	Consumption/Efficiency/Climate change mitigation, Electric mobility/Alternative fuels/ Refilling and charging infrastructure, Shift to environmentally-friendly modes of transport

Table 7.1: Energy consumption by mode of transport and increase compared with the baseline year and the preceding year

	2016 in PJ	2016 % share	% change on 2015	% change on 2005
Road	2,241.5	83.1	2.29	4.26
Air transportation*	389.4	14.4	7.52	13.03
Rail	52.7	2.0	-2.25	-32.65
Inland waterways	12.4	0.5	-7.06	-8.75
Total	**2,696**	**100**	**2.87**	**4.25**

Source: Working Group on Energy Balances, 08/2017
*including international air transport

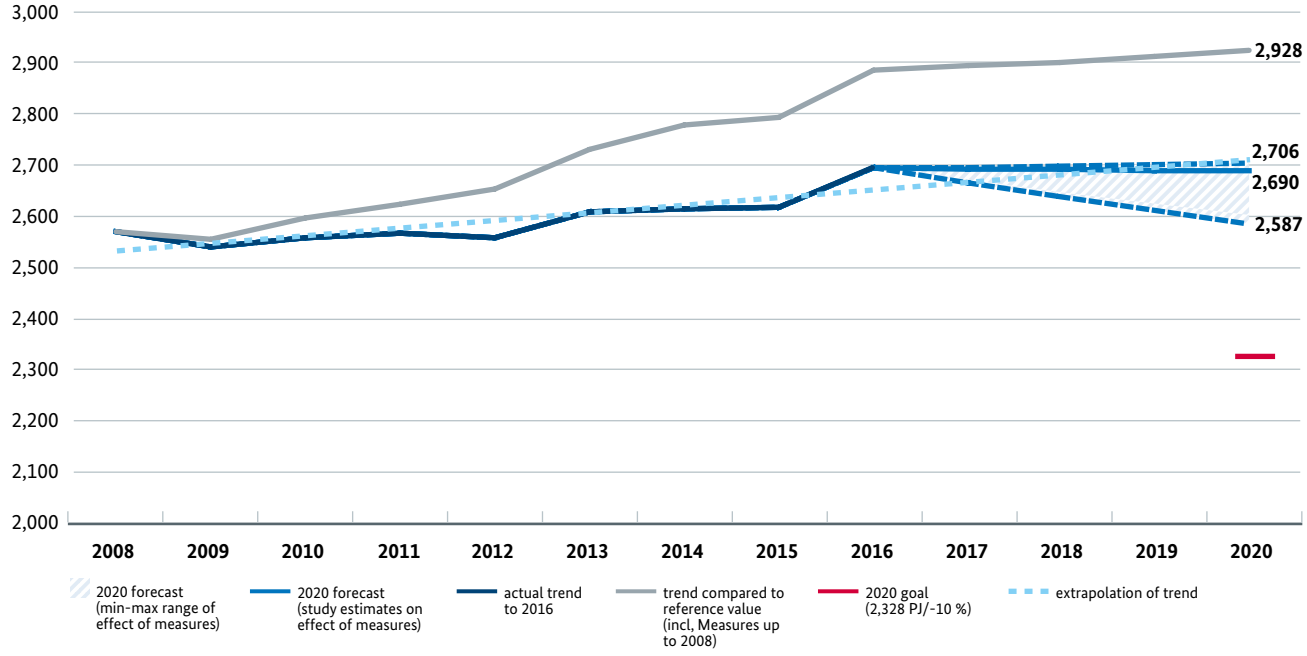
Final energy consumption in the transport sector has increased by a total of 4.2% compared against the baseline year, 2005. Final energy consumption in the transport sector has therefore increased annually by around 0.4% on average since 2005, and by as much as 0.9% annually since 2010. Based on the expert commission on the 5th Monitoring Report on the Energy Transition, it is expected that the 2020 Goal (10% reduction) will not be reached until around 2030 under the present circumstances. In light of this, considerable additional efforts will be required to turn this trend around as soon as possible. A linear extrapolation of the trend since 2005 would indicate that the 2020 Goal would be exceeded by 15.8%. In order to drive down the final energy consumption in the transport sector by 10% by 2020, this figure would have to drop by a total of 13.7% compared to 2016 in the coming four years, and annually by an average of 3.6%. This is improbable.

The Target Architecture Study (see Chapter 2.2) conducted analyses that arrived at the following scenario: The goal of cutting final energy consumption in the transport sector by 10% compared with 2005 will be missed by a wide margin. The study assumes that this percentage will even increase by around 4.6% by 2020 (within a range of -0.6% to +5.3%, see Diagram 7.2). This takes the effects of measures taken under the Target Architecture Study into account.

There was a significant increase once again in the passenger kilometres travelled and the volume of freight moved in 2016. The number of passengers or goods transported is multiplied by the total transport distance in a given period to calculate the passenger kilometres travelled or the freight moved, respectively. The passenger kilometres travelled and the volume of freight moved have increased by 11.0% and 21.7% respectively since 2005, and by 2.3% and 0.5% respectively compared with the previous year.

Specific energy consumption has decreased among the current fleet of passenger cars, but is stagnant among heavy goods vehicles (HGV). In the case of the current fleet of passenger cars and light commercial vehicles, average consumption per 100 km fell by 7,5% between 2005 and 2016, and by 0.6% compared with the previous year. This demonstrates that the transport sector is also becoming more efficient, particularly through the use of enhanced drive technologies. Efficiency gains here are mainly the domain of the petrol engine, however, while the efficiency of diesel engines has hardly increased. A study conducted by the ICCT found that, given the vehicle efficiency of the current vehicle fleet, no appreciable increase in efficiency has been achieved among HGVs in Europe since 1997, based on average consumption per 100 kilometres, and irrespective of the duty cycle (Lastauto-Omnibus 2015, a German trucking magazine, in ICCT 2015). Growing demand for higher engine power, in particular, has prevented this from happening.

Diagram 7.2: Reduction of final energy consumption in the transport sector according to the Target Architecture Study
in PJ



Source: Prognos, Fraunhofer ISI, DLR (2018)

Efficiency gains are unevenly distributed across the various modes of transport. A comparison of the specific consumption rates across all transport modes based on the Federal Environment Agency's TREMOD model reveals that the greatest efficient gains can be found in rail transport, which clearly exceed on-road efficiency improvements: in the area of freight transport, specific on-rail consumption dropped by more than 30% between 2005 and 2014, and even by more than 40% in the area of passenger transport. This method is based on the average consumption per passenger-kilometre in passenger transport and per tonne-kilometre in freight transport, and therefore also includes improvements in efficiency as a result of load management and fewer empty runs in freight transport.

The average fuel consumption of newly registered passenger cars and light commercial vehicles has dropped in recent years. In the period 2005–2016, the average consumption for vehicles with petrol engines dropped by 25.7%, and by 26.3% for diesel engines, as indicated by official figures from the Federal Motor Transport Authority. These numbers, however, reflect only the trends in information provided by the manufacturers that was collected during the type approval process, and do not take into account the discrepancy that has grown through the years between consumption figures and actual operation. For this reason, the Federal Government is working hard to ensure that the new WLTP type approval for passenger cars and light commercial vehicles, which encompasses an enhanced test procedure and better test parameters, is implemented quickly in order to increase the plausibility of the CO_2 type approval values and ensure better reproducibility. In the end, vehicle customers should be given a more accurate picture of consumption when comparing manufacturer claims with their own experience.

A reversal of the trend in the transport sector, with significantly lower energy consumption, is and will remain a long-term project. Overall, final energy consumption in transport runs contrary to the goals of the Energy Concept. So far, efficiency improvements have been unable to offset growing energy consumption in the transport sector resulting from the significant increase in the volume of traffic. With the Mobility and Fuels Strategy and the 2020 Climate Action Programme, the Federal Government therefore established a mix of support, advice, funding and an enhanced regulatory framework as early as 2014, which is designed to further reduce final energy consumption in the transport sector (see Chapter 7.4). In addition, the focus is already on the use of technical innovations resulting from R&D funding and associated programmes to take the innovations to market (see Chapter 14), as well as the potential of digital solutions (see Chapter 13.2).

Automated and connected driving will redefine mobility in motorised private transport, freight transport and public passenger transport. Automated and connected driving is an innovative technology at the interface of mobility and digital advances which on the one hand can contribute to increased traffic safety and efficiency as well as reducing mobility-related emissions, and on the other hand, can give rise to new business opportunities in the service and mobility sectors. The Federal Government launched the Automated and Connected Driving Strategy to implement measures regarding infrastructure, legal framework, innovation, con-

nectivity, IT security and data protection, as well as public dialogue. This includes the Eighth Act amending the Road Traffic Act, which provides for more legal certainty for innovation in the areas of highly-automated and completely-automated driving – both for the consumer and industry as well. On the basis of recommendations presented by the Ethics Commission for Automated and Connected Driving, the Federal Government also agreed on an action plan for creating ethics rules for self-driving computers (see Chapter 16).

Due to the increasing need for transportation, it will be more important than ever to break the link between traffic volume and energy consumption. Assuming continued economic growth, the 2017 Projection Report specifically forecasts a strong increase in demand for transport in road freight transport up to 2035. Even if all the measures adopted by July 2016 were implemented, energy consumption would still only decrease marginally. Germany looks set to fall short of targets post-2020 also, as there is no sign of major progress, at least in the short term, with regard to the use of alternative drives in road freight transport and with regard to moving freight from road to rail (see Chapter 7.2 and 7.3).

European legislation to reduce the CO_2 emissions of road vehicles must be developed further with ambitious targets for the post-2020 period in order to meet energy consumption and climate goals at national and European level. The EU legislation to regulate the CO_2 emissions of road vehicles is currently an effective instrument to cut energy consumption, and thereby significantly reduce greenhouse gases in the transport sector. It is crucial that this legislation be updated and refined specifically and for all vehicles for the post-2020 period. After all, the early announcement of specific CO_2-reduction goals for new vehicles is central to bringing CO_2-reduced vehicles more quickly to market (and also electric mobility, see Chapter 7.2) and gives industry and consumers planning security. According to the 2050 Climate Action Plan, the transport sector must also provide a substantial contribution to lowering CO_2 levels. The Federal Government is working hard – particularly at the EU level – to ensure that the CO_2 regulation for new passenger car fleets and light commercial vehicles will continue to be enhanced for the period after 2020, with ambitious but realistic goals. The planned introduction of a new standard for CO_2 emissions and fuel consumption for commercial vehicles is also a positive development. Fuels made with electricity generated from renewable sources will be promoted in the long term – especially in air and sea transport – using quotas for fuel suppliers.

More use must also be made of opportunities to reduce transportation demand and traffic volumes. This can be achieved by increasing system efficiency in the transport sector, such as through integrated land-use and traffic management planning or through compact interlinked journeys. The continued development of the Mobility and Fuels Strategy will place more attention on these areas in the future (see Chapter 16).

7.2 Alternative fuels and innovative drive technologies

The energy transition in transport can only succeed with a substantial increase in the portion of alternative drivetrains and fuels. The energy concept is based on rapid expansion of use of electric vehicles (battery-powered vehicles and fuel-cell-powered vehicles) on German roads. Another focus of the Energy Concept is the strengthening and expansion fuels produced with renewables and alternative fuels in connection with innovative drive technologies. Electric mobility and other alternative drives already enable no-carbon or low-carbon mobility as well as energy-efficient mobility. Overall, however, their share in the volume of traffic has been relatively small so far. Biofuels produced with residue and waste material can also contribute to reduced CO_2 emissions in mobility in the years to come. Furthermore, hydrogen produced by sector coupling or renewably can be made available to the transport sector. Hydrogen can be used for producing low-carbon, synthetic fuels (e.g. methane, DME, OME, etc.) or can be used for operating fuel cells. Competing uses between the various sectors must be taken into consideration. Use of electricity-based fuels is especially suited to air and sea transport.

Electric mobility is the key to applying the energy transition successfully in the transport sector. Electric drivetrains allow for flexible use of various energy sources and recovery of kinetic energy. Energy and cost efficiency of the various energy storage devices for specific mobility applications will be decisive for their utility.

The number of electric drive vehicles is increasing rapidly, but the market share is still small. As shown in Diagram 7.3, around 62,500 battery-powered 3-wheel-plus vehicles were registered in 2016, around 21,000 of which were externally chargeable hybrid electric vehicles. However, their market share remained at less than 0.8% of new passenger car registrations. In addition to 3-wheel-plus electric drive vehicles, increasing numbers of two-wheel electric vehicles, such as pedelecs and e-bikes, can be seen on German roads.

Future mobility will be sustainable, interconnected and increasingly energy efficient – particularly rail transport – but also passenger car traffic. Alternatively-fuelled vehicles are the key to sustainable and climate-neutral mobility in the long term. E-mobility is a major focus of activities. The priority now is to speed up the development of a market for such technologies. The number of electric cars (without hybrids) has increased more than tenfold overall since 2010. They are either battery-powered or use fuel cells that convert

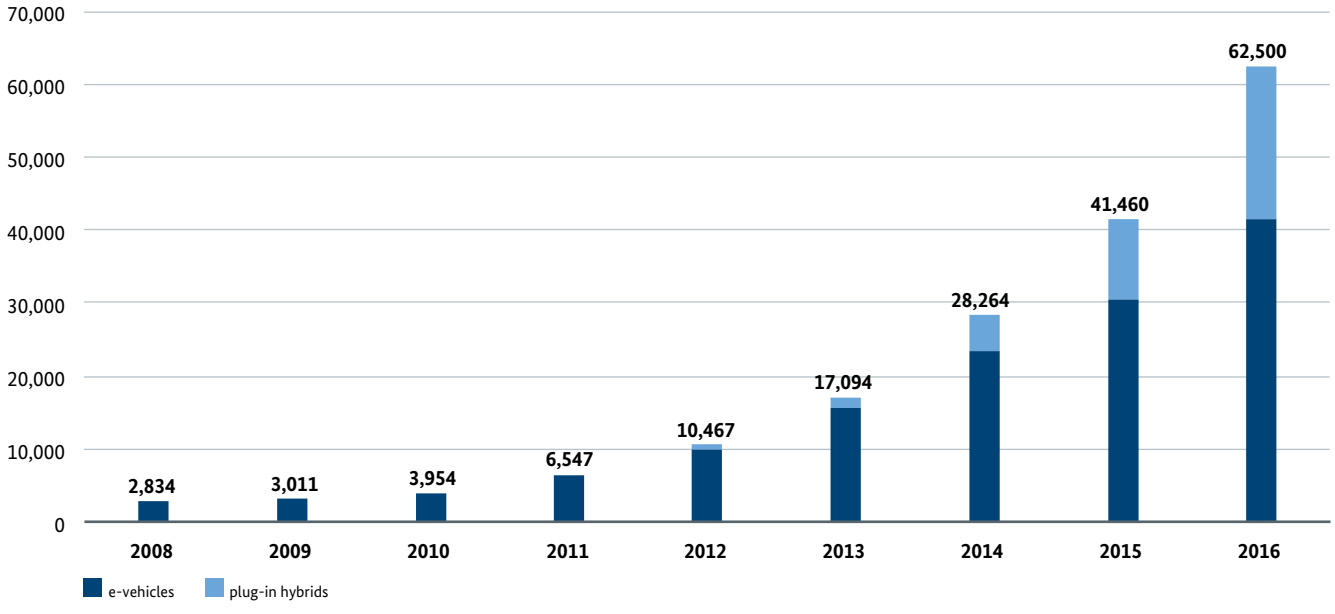
hydrogen into electric power in the vehicle. The goal is to make Germany a leading market and provider for electric mobility and thereby entice the entire value-added chain to set up business here. The eco-bonus will be provided up to 2019 at the most for promoting sales of electrically operated vehicles. A total of €600 million has been set aside for this programme.

More renewable energy will make mobility climate-friendly. The share of renewables in the transport sector still stands at 5.2% in 2016 and is to increase (see Chapter 4.4). This requires that renewables are increasingly used to generate electricity (see Chapter 4.2). This reduces the specific carbon dioxide emissions of the electricity used in electric cars.

In addition to electric drivetrains, the efficiency gains of these vehicles also play an important role. A relatively energy-efficient option is to directly use electricity from renewable energy sources for decarbonisation of the transport sector, wherever possible. (see Chapter 13.1). As a study commissioned by the Federal Ministry of Transport and Digital Infrastructure illustrates, electrification through sector coupling and energy efficiency in the transport sector go hand in hand (DLR et al. 2016a). However, there must be an assessment of what is required to meet the potentially sharp increase in the demand for electricity, such as adequate domestic and international generation capacity from renewables and an efficient power grid infrastructure, and – where it is economically feasible – such infrastructure must be provided. At the same time, electric mobility is not yet concurrently in some parts of the market, so that expansion of electric mobility still lags behind earlier expectations. This makes it all the more necessary to consider all existing vehicle technologies (including hybrids and lightweight construction) and fuels that are cleaner and produce less CO_2. However, the sometimes long investment cycles in the transport sector must be considered, and it is essential to avoid getting locked into only slightly more effective technologies. Existing infrastructure and conventional powertrain technology can already utilize power-to-x products based on green hydrogen, which increases technical flexibility. These products are especially attractive in areas for which electric mobility will not be technologically feasible for the immediate futures (e.g. air and sea transport). However, due to the high amount of energy used to produce power-to-x products as well as the as yet expensive and technically complicated manufacturing methods (e.g. industrial carbon production), this technology will not be available for the immediate future.

Renewable fuels will be used increasingly for transport. In the long term, the use of renewable fuels is the only way to wean shipping and air travel off their dependency on fossil fuels. As the potential of biomass is limited, the vast majority of these fuels might be produced on the basis of electrical energy from renewable sources. Both fuel options still offer sufficient potential for efficiency gains and cost cutting in production. This applies, in particular, to the electrolysers needed by both fuel types for the production of hydrogen. Federal funding covers plug-in hybrids to battery drivetrains, fuel cells and more recently, sector coupling by using electricity-based fuels (see Chapter 16). The Federal Government will step up its research efforts (particularly in the area of electrolyser material and surface research) to leverage poten-

Diagram 7.3: Number of 3-wheel-plus electric vehicles
Number



Source: Federal Motor Transport Authority, 09/2017
From 2012, also includes plug-in hybrid vehicles and range extender vehicles

tial for boosting efficiency as soon as possible. It is also expected that market ramp-up of fuels produced with renewables will lead to economies of scale and efficiency gains in the transport sector. The use of these alternative fuels does not alter the issue of energy consumption, which remains on a par with that of present-day fossil fuels.

Biofuels from waste and residues are gaining in importance. Currently, the share of biofuels used to reduce CO_2 emissions accounts for only 4.6% of energy consumption in the transport sector. In the future, incentives are planned to utilize the potential of "progressive" biofuels produced from waste and residue waste. These biofuels could contribute largely to reducing CO_2. At the EU level this development should be given a strong impetus with the new draft Renewable Energy Directive.

Electric buses also play an important role in the reducing CO_2 and pollutant emissions in transport. In recent years, the Federal Government has promoted a wide range of projects to support the electrification of the road-bound public transport network, aiming to establish zero-emission and low-emission vehicles faster in the market. An increasing supply of battery-powered buses, in particular, has been observed on the market, attracting rapidly growing interest from transport service companies, with concrete plans for procurement in some cases. The findings of a study commissioned by the Federal Ministry of Transport and Digital Infrastructure revealed that hybrid trolley buses also offer particular potential on busy routes (DLR et al. 2016b). The Federal Government is already promoting the use of hybrid trolley buses in cities. The additional emissions reductions that are needed can also be achieved here through the use of electric drives, inter alia, which are already being trialled in HDVs for regional deliveries. The Federal Ministry for the Environment is currently making preparations to field-trial a hybrid trolley truck under real conditions. To promote plug-in hybrid and electric buses in urban public transport, the Electricity Tax Act was amended on 1 January 2018 to lower the tax rate to €11.42 (see Chapter 16).

The number of fuel cell vehicles already available on the market is growing, but successful market breakthrough still needs some time. The mobile application of fuel cells in conjunction with hydrogen technology in a vehicle involves supplying electricity to the electric drive via a fuel cell that is powered by hydrogen as the secondary fuel. There are currently some 500 hydrogen and fuel cell vehicles in Germany. The Federal Government has been promoting hydrogen and fuel cell technology for ten years, investing a total of €1.4 billion in the period 2006–2016. Numerous transportation projects have been successfully instigated for the roads, rails, air and ship traffic. This funding will be continued in the period 2016–2025. About 40% of the funds are to be made available for research, development, demonstrations and market readiness, and about 60% for the respective fixed-term marketing support activities. Representatives of the German hydrogen and fuel-cell industries and academic communities announced in 2015 their intent to invest more than €2 billion over the next 10 years in research and development and in the market ramp-up of related products. In addition, the Federal Government aims to create a stable funding scheme of up to €1.4 billion during this period. Funds will be provided by the individual budget estimates of the government departments responsible for these programmes.

Gas-based mobility is to become a fixed component of the transport sector energy transition. Liquefied natural gas and compressed natural gas offer great potential for cost-effectively reducing pollutants and CO_2 in regional and municipal mass transit and for passenger cars. By using a blend of biomethane or synthetic methane, natural-gas-powered vehicles could become as climate-friendly as electric vehicles (depending on the electricity mix). Natural gas is a fuel of the future, particularly in the shipping sector. The main advantage of natural gas is the significantly lower level of pollutants it emits and less noise in comparison to engines operated with marine diesel fuel or heavy fuel oil. Therefore, natural gas-based mobility in the form of liquid natural gas (LNG) is a possible alternative to marine diesel and heavy fuel oil, particularly in the maritime and inland waterways transport sector, i.e. precisely in an area which has been associated with high emissions of pollutants up to now. If the sector were to switch to fossil-based LNG, using all available technical possibilities, the greenhouse gas balance could be improved with the reduction in carbon dioxide emissions. However, to achieve climate protection targets in shipping traffic it will be necessary to switch to fuels based on regenerative energy sources.

The number of natural gas passenger cars stands at around 80,000. The number of annual new vehicle registrations varies greatly and has recently increased significantly. In talks with representatives from the automotive in December 2015 it was agreed for natural gas to have a 4% share in the fuel market in the road transport sector by 2020. Accordingly, the Federal Ministry for Economic Affairs and Energy set up the Round Table on Gas-based Mobility. In addition, the amended Energy Tax Act and Electricity Tax Act have been in effect since January 2018. These amendments provide for continuation of tax breaks for natural gas up to and including 2026, with a digressive gradual reduction starting in 2024. Tax breaks for LP and LNG will be gradually decreased starting in 2019, and by 2023 the regular tax rates should apply. These tax breaks serve as an incentive to use NO_x-free and CO_2-reduced public and private transportation in the inner cities (see Chapter 16).

The infrastructure for alternative drive systems calls for faster infrastructure expansion and uniform standards. In order to create the charging infrastructure required for battery electric vehicle and the hydrogen refuelling points for fuel cell powered vehicle, the following progress has recently been made:

- Most charging is done at home or work. These private normal power recharging points can take care of a large portion of daily distances travelled. For trips requiring additional charging there must be a public high power charging infrastructure, for which there is currently no connected and comprehensive network. According to the German Association of Energy and Water Industries (BDEW), at the end of 2017 there were about 10,700 charging points available to the German public, and of those, 530 were high power recharging points. Currently the fast charging stations are primarily located on routes connecting large cities. According to the Federal Ministry for Transport and Digital Infrastructure, around 300 of the approximately 400 motorway sites were equipped with high power recharging points and sufficient parking spaces. The upgrade of remaining sites to high power recharging points is still underway. The goal is still to equip all sites with high power recharging points, if possible.

- According to data from the National Organisation for Hydrogen and Fuel Cell Technology (NOW), 45 hydrogen filling stations for fuel cell vehicles were in operation or had been completed by March 2018. In Germany, industry is responsible for the expansion of the hydrogen infra-

structure. Participating companies joined forces to set up the organisational basis to put in place a nationwide network of hydrogen refilling stations and thereby ensure the supply of hydrogen throughout the country. The development of a hydrogen supply infrastructure for fuel cell vehicles can be supported through the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP), which has been extended for the period 2016–2026 (see Chapter 14).

- According to surveys conducted by the Initiative for Natural Gas-based Mobility, the filling station network for compressed natural gas (CNG) comprised over 900 stations at the start of 2016, the majority of which were integrated into existing filling stations. The first LNG filling station for HDVs was opened in Ulm in 2016. The second LNG refuelling point was opened in April 2017 in Grünheide near Berlin as part of a pilot project of the Federal Ministry for Transport and Digital Infrastructure. There are currently more than 20 additional LNG refuelling points planned with funding from the Connecting Europe Facility. Bunkering facilities for LNG are already available in a number of ports.

Current measures to sponsor construction of a comprehensive charging infrastructure: The amendment of the Charging Station Ordinance allows motorists to use web-based payment systems to pay for electricity at all public charging points. In order to increase the attractiveness of electric mobility and encourage consumers to buy e-vehicles, a sufficient charging infrastructure is needed, not only in the metropolitan regions but also in rural areas and tourist regions. The Federal Ministry of Transport and Digital Infrastructure instigated the programme Electric Vehicle Charging Infrastructure in Germany for the period 2017 to 2020 to fund a comprehensive and demand-oriented charging infrastructure for battery electric vehicles with at least 15,000 charging stations all over Germany (see Chapter 16). The Guidelines on the Provision of Grants for Equipping and Converting Sea-Going Ships to Use LNG as a Marine Fuel adopted on 17 August 2017 is a tool of the Ministry of Transport to fund new-builds of LNG ships or to adapt existing ships to LNG/Dual-Fuel drives, including auxiliary equipment, with a subsidy of 40%–60% of the costs of upgrading to LNG. Several call for applications for funding are planned for the funding period up to 31 December 2020.

The goal is – in addition to climate and environmental protection as well as occupational safety and health – to increase demand for LNG as a marine fuel in Germany in order to provide incentives to companies in the gas sector to create the required LNG supply infrastructure in harbours. An indirect impetus for expanding the LNG infrastructure can also be provided by demand from pilot funding measures of the Transport Ministry for inland waterway and maritime navigation (upgrading a container feeder to LNG, construction of a new ferry for Lake Constance) and by subsidizing federal ships for LNG upgrades. The Transport Ministry also provides funding for heavy goods transport as part of a pilot project with haulage firms to purchase LNG-powered HGVs and natural gas-powered HGVs using up to 100% biomethane. These projects are scientifically monitored to determine emissions and consumption of the drives when in operation.

The Federal Government wants to create sustainable and climate-friendly mobility, at the same time, driving restrictions should be avoided, and health hazards should be minimised. To counteract nitric oxide (NO_x) emissions in inner cities that continually exceed the thresholds, the Federal Government launched a dialog with the automotive industry, the Länder and municipalities to develop a number of measures that are to be implemented by 2020. In August 2017 the fund Sustainable Mobility for the City was launched, in which the automotive industry also participates. The fund was rolled over into the Clean Air 2017–2020 immediate action programme, which aims to finance implementation of measures in municipalities where nitrogen dioxide thresholds are exceeded (see Chapter 16). This programme aims to reduce nitrogen dioxide emissions in order to help municipalities stay under the thresholds. The focus is on electrification of urban vehicle parks (e.g. taxis and public buses), including expansion of charging infrastructure and measures on stabilising the power networks, upgrading diesel buses to low-emission motors, improved traffic management and digitalization of municipal traffic routing.

7.3 Shift to environmentally-friendly modes of transport

For the energy transition in the transport sector to succeed, large segments of traffic must shift to rail and public transport services. According to the Energy Concept, the aim is to put the necessary framework in place to move traffic to more environmentally-friendly forms of mobility as an alternative to motorised private transport. The coalition agreement between the CDU, CSU and SPD contains provisions that aim to attract twice as many rail passengers by 2030 by means of a rail pact between government and industry, and thereby also shift more freight traffic to the rails. The measures of the Rail Freight Masterplan are to be implemented permanently. The railways should in turn invest in better service and reliability as well as more innovation.

Shifting traffic to rail could make a significant contribution to meeting the goal of a 40–42% reduction in transport-related greenhouse gas emissions in the 1990–2030 period, as agreed in the Federal Government's 2050 Climate Action Plan. With regard to final energy consumption, shifting to rail could also contribute to a 20% reduction in final energy consumption in the 2005–2030 period. This, in turn, would be an important contribution to the 40% reduction in final energy consumption in the period 2005 to 2050, as required by the Energy Concept of the Federal Government.

While the volume of freight moved by rail has increased overall in recent years, its share in total freight moved has stagnated. Owing to the sharp increase in the volume of freight traffic in recent years and the dominant role of road freight transport, CO_2 emissions and final energy consumption of freight traffic in Germany have risen slightly in recent years. This trend is projected to continue in the coming years according to the 2030 Traffic Forecast. In addition, the 2017 Projection Report anticipates that the measures adopted up to 2016 inclusive and the efficiency gains in road traffic (see Chapter 7.1) will not be enough to deliver on the energy consumption and CO_2 emission reduction goals in the freight transport sector. Increased use of rail could help achieve the goal if the appropriate infrastructure, rolling stock and logistics concepts are in place, as many trains are already electric, and therefore offer considerable energy efficiency. The share of renewables in the rail electricity mix is also growing steadily. Rail freight transport volumes dropped, however, by 0.4% to 116.2 tonne kilometres, yet was 21.7% above the 2005 level. In 2016, 364 million tonnes of freight were transported on the German public railway network, according to information from the Federal Statistics Office. In recent years, however, the share of freight moved by rail in total freight moved has slowly dropped since 2011, also remaining below the 18% mark in 2016. A study carried out for the Federal Environmental Agency (INFRAS and Fraunhofer-ISI 2016) showed that an increase of another 5% to 23% by 2030, and to 30% by 2050 is possible if ambitious measures are taken, including expanding and raising the HGV toll, raising and differentiating the track assess charges to strengthen the user pays principle for rails, or raising the total capacity in rail freight traffic by 60% to 70%.

An automated and digitised rail freight transport system is needed to improve the competitive position of rail freight transport compared with road freight transport. The coalition agreement between the CDU, CSU and the SPD aims to encourage digitisation of the rails, also on the heavily-used S-Bahn (fast regional train) routes, and to support expansion of the European Train Control System (ETCS) and electronic switches as well as upgrading locomotives with federal funds. Research and funding is provided for automation of freight traffic and autonomous driving on the rails. Further to this, the Federal Government is supporting the construction and expansion of intermodal terminals for intermodal transport and private sidings by providing financial contributions towards the construction of the infrastructure (see chapter 16).

Even though the number of kilometres travelled by local public passenger transport is increasing overall, the share of local public passenger transport in total passenger transport remains largely unchanged. In Germany, cars are used to travel short distances, which account for the majority of consumption and emissions in passenger transport. According to the Federal Statistical Office, passengers used scheduled local and long-distance buses and trains nearly 11.2 billion times in 2016, and in 2017, more than 11.5 billion times. This corresponds to a growth rate of more than 1.1 over last year. On average, in 2016 31 million passengers were transported with scheduled services and in 2017, 31.5

Table 7.2: Reduction in final energy consumption by exploiting potential to shift traffic to rail

Forms of transport	Reduction in final energy consumption in 2030 in PJ compared with 2010 according to studies by the German Aerospace Centre (DLR)	Reduction in CO_2 emissions in 2030 in million tonnes compared with 2010 according to studies by the German Aerospace Centre (DLR)
Freight transport	98	8.5
Long-distance passenger transport	15	1.2
Short-distance passenger transport	102	8.6
Transport total	**215**	**18.3**

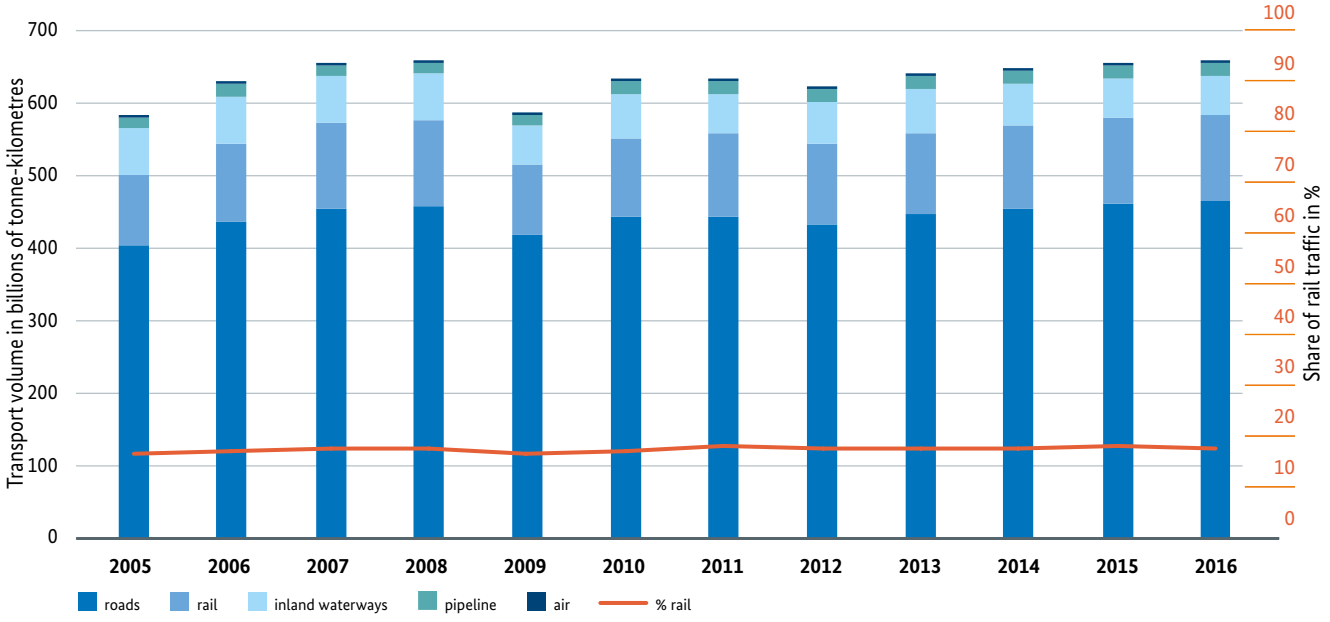
Source: DLR et a. 2016c, d

million. The number of passengers in local and regional regular services has continually increased since 2004, the first year in which comparable data was collected. In 2017, the number of passengers was almost 1.4 billion higher (+14%) than 12 years previously. There was particularly strong growth during this period in rail transport (+37.7%) and trams (+20.3%). Despite this upward trend, the share of local public passenger transport in total passenger transport has been consistently below 10% for a number of years.

To make more of the opportunities offered by public transport, the public transport system needs to be consistently strengthened nationwide. According to studies commissioned by the Federal Ministry of Transport and Digital Infrastructure and the Federal Ministry for the Environment, there are many ways to capitalise more on the potential of the local public passenger transport system (DLR et al. 2016e; Institute for Applied Ecology et al. 2016). Findings of the Oeko-Institute study reveal that a smarter parking policy, in particular, can improve the competitiveness of the public transport system. In this context, the authors recall the moderation and coordination role of the Federal Government and call, inter alia, for the "Development of a National Local Public Passenger Transport Strategy". Responsibility for planning, designing, organising and financing local public passenger transport, including local passenger rail services, lies with the Länder and municipalities, however. Among other measures, the Federal Government aims to lend significant support to the Länder and municipalities to finance the local public passenger transport system. Regionalisation funds were raised to €8.2 billion in 2016, increasing to €8.5 billion in 2018. This amount will be augmented annually by 1.8% to reach €10.7 billion by 2031. In addition, under the provisions of legislation on unbundling (Entflechtungsgesetz), the Länder receive annual compensation payments of around €1.336 billion to improve transport conditions in the municipalities, as well as federal financial assistance totalling €332.6 million on the basis of the federal programme under the Local Authority Transport Infrastructure Financing Act.

In future, the expansion of the public transport system should increase its contribution to reaching the goals of the energy transition. For this reason, the Federal Government set out to make public transport more climate-friendly in the 2020 Climate Action Programme. Not least, the Federal Government promotes mobility management for companies and innovations in the local public transport system, such as better passenger information systems and electronic tickets. The Initiative for Digital Connectivity in Public Passenger Transport supports such activities. To substantially increase regular-interval long-distance rail services and benefit more passengers with direct connections in long-distance traffic, the coalition agreement between the CDU, CSU and SPD provides for efforts to accelerate the nationwide integrated regular interval timetable (Deutschlandtakt). In addition, the aim is to also move forward with the expansion of the tram, light rail and metro networks and the electrification of urban bus transport.

Diagram 7.4: Share of freight moved by rail in total freight moved



Source: Transport in numbers, 2017/2018

As the central infrastructure instrument, the Federal Transport Infrastructure Plan has the potential to drive forward the transfer of traffic to efficient, low-emission modes of transport. The 2030 Federal Transport Infrastructure Plan adopted in August 2016 is the basis for maintaining and expanding the German transport infrastructure. This plan contains legislation that funds expansion and new construction for the three main transport methods – road, rails and waterways. It mainly serves to create a demand-oriented transport network and focuses in particular on the specific goals of transport policy that the development of the transport infrastructure can specifically influence. A strong infrastructure is essential for seamless mobility in passenger transport and an efficient freight transport system. The 2030 Federal Transport Infrastructure Plan, and the infrastructure expansion legislation derived from this plan, also influence to a certain extent energy consumption in the transport sector and therefore progress towards the energy transition goals in this sector to 2030 and beyond. The prioritized new and expansion projects of the Infrastructure Plan for the rail and waterway network cause traffic flows to shift, resulting in a reduction in the energy input and therefore CO_2 emissions of the transport sector. Altogether, the 2030 Federal Transport Infrastructure Plan will result in reductions of up to 0.4 million tonnes of CO_2 per year. This is equivalent to around 0.2% of current emissions in the transport sector, and is the result of measures to strengthen climate-friendly transport modes. For the first time ever, the Federal Transport Infrastructure Plan also mentions the cycling infrastructure, particularly the greater participation of the Federal Government in the future construction of fast bike lanes.

Implementation of the Rail Freight Masterplan: Rail freight traffic will be made viable for the long term with measures provided by the Masterplan. One measure sees the reduction of rail access charges in rail freight traffic with additional federal funds of €350 million annually, beginning in 2019, and if an evaluation in 2021 sees progress, will be extended to 2023.

7.4 Instrument mix in the transport sector

In the Fourth Monitoring Report, the Federal Ministry of Transport and Digital Infrastructure was asked to present information concerning the effectiveness of new measures towards meeting the targets in the transport sector in subsequent Monitoring Reports, and to take further measures where needed. According to estimates of the scientific advisory consortium for the Mobility and Fuels Strategy appointed by the Federal Ministry of Transport and Digital Infrastructure, the transport measures adopted thus far will deliver a 148 PJ reduction in final energy consumption in the transport sector in the period from 2005 to 2020. This equates to a reduction of 5.7%. One of the reasons for the gap between this figure and the envisaged 10% reduction target is that it is now thought that an HGV toll that depends on vehicle CO_2 emissions or energy efficiency categories to replace the current HGV toll, which depends on the class of pollutant, will have a weaker impact. Demand for funding measures in the area of battery-powered electrical mobility and in the National Hydrogen and Fuel Cell Technology Innovation Programme has been growing for years. Applications to both programmes regularly outstrip availability of funds. The new financial assistance programmes and the charging infrastructure programmes have also exceeded expectations. This trend correlates to the dynamic increase in e-vehicles since 2010.

Transparency and participation: The mFUND research initiative and public involvement in the 2030 Federal Transport Infrastructure Plan

mFUND research initiative

The Federal Ministry for Transport and Digital Infrastructure has provided €150 million of funding for the mFUND research initiative to assist digital data-based innovations for Mobility 4.0.

- The goal is to make mobility more efficient, safer and more climate-friendly for all modes of transport and to open up new business possibilities by making government data available to the public.
- In the mFUND Fund 2 (funding for projects up to €3 million), three invitations to submit have been published, and one line of funding in Fund 1 (funding up to €100,000) can be applied for at any time and without a deadline.
- Since the programme was started in June 2016, a total of 367 project drafts have been submitted by more than 1,080 participants.
- Implementation of the mFUND is accompanied by PR events (especially mFUND conferences, start-up pitches and hackathons) and internet information.
- mFUND brings together creative individuals from start-ups, associations and higher education institutions, creating a network of players in government, business and research.
- This makes mFUND an important motor for dialog in the transport sector.

Public participation in the 2030 Federal Transport Infrastructure Plan

In comparison to earlier transport infrastructure plans, the Federal Transport Ministry significantly expanded its outreach to the expert community and citizens when drafting the 2030 Federal Transport Infrastructure Plan. This includes all of the preparatory phases of the Transport Infrastructure Plan, which overlap time-wise:

- A transparent process has been used since 2011 in the planning and forecast phase to involve experts and the public in determining the appraisal methodology and the guidelines of the Plan. In addition, an updated traffic forecast was prepared for 2030.
- The appraisal phase started in 2012, with review and assessment of the projects submitted by associations and citizens, among others.
- When drafting the 2030 Plan, the Transport Ministry consulted the Länder, federal government departments, associations and citizens in the participation, consultation and decision phases.

The goal of participation is to achieve a high degree of transparency and create multiple opportunities for involvement. In this way the various perspectives can be meaningfully brought into the drafting process and properly evaluated in order to achieve a suitable solution. Creating broad acceptance of the Plan is also an important goal, but should not be the only basis for federal decisions. Due to the complexity and multifaceted interests involved, when conflicts of interest arise it is not always possible to reach a consensus with all participants. The 2030 Federal Transport Infrastructure Plan is and will remain a professional assessment of the investment required for transport infrastructure.

Additional central topics of the coalition agreement between CDU, CSU and SPD for the energy transition in the transport sector

- Continuation of the investment ramp-up for transport infrastructure and permanently ensuring the transfer from of unused budgetary funds to the next budget year
- Sufficient financing of prioritised projects of the 2030 Plan
- Improvement of municipal and regional services transport conditions (Local Authority Transport Infrastructure Financing Act: GVFG)
- Sustainable Mobility for the City fund, mobility plans for reducing pollutants and funding for measures provided for in the fund
- Shifting commuter traffic to the rails, also using P+R (park and ride)
- Strengthening rail transport with the rail pact with the goal of doubling passenger traffic by 2030 and increasing rail freight traffic
- Implementation of the Rail Freight Masterplan
- Realisation of prioritised measures of a 740m network
- Driving the digitisation of the rails, also on the heavily-used S-Bahn (fast regional train) routes
- Expansion of the European Train Control System (ETCS) and electronic switches as well as upgrading locomotives with federal funds
- Research and funding is provided for automation of freight traffic and autonomous driving on the rails
- The target is to electrify 70% of the German railway network by 2025
- Lower track access charges
- Implement the Deutschlandtakt (nationwide integrated regular interval timetable)
- Develop the eTicket in local public transport nationwide
- Create a specific research programme for rail transport
- Establish a German rail transport research centre
- Support research into rail noise and measures for improved rail noise abatement
- Innovation bonus for acquiring and rebuilding railcars and locomotives
- Investing in electric mobility, including hydrogen and fuel cells: Sponsoring battery cell manufacture in Germany, creating a charging infrastructure with 100,000 charging points by 2020
- Creating battery cell manufacture in Germany
- Promoting hydrogen technology
- Creating an LNG infrastructure
- Continuing the National Innovation Programme for Hydrogen – and Fuel Cell Technology
- Sector coupling should be encouraged and the regulatory framework modified to include use of “green hydrogen” and hydrogen as the product of industrial processes for fuels, or for producing conventional fuels (e.g. natural gas).
- Production of biofuels based on waste and residual matter as well as plants
- Greatly increase German electric mobility (battery electric vehicles, hydrogen and fuel cells), by reducing the EEG surcharge on battery-operated buses, reduced taxation of company cars for electric vehicles, among other things
- Further development of the National Platform on Electric Mobility to become a National Platform on the Future of Mobility
- Digital test beds for the roads (particularly in cities), rails and waterways
- Open-data applications are intended to simplify human mobility and transport of goods.
- Technologically neutral initiatives to benefit alternative drivetrains and energy sources in shipping and in harbours (LNG, hydrogen/fuel cells, methanol and electric mobility) should be encouraged.
- Digital technologies and automated operation in shipping, harbours and maritime supply chains should be promoted.

Central measures in the transport sector

Consumption/efficiency/climate action

- Continued development of the 2013 Mobility and Fuels Strategy
- New World Harmonised Light Vehicle Test Procedure (WLTP)
- Strategy for Automated and Connected Driving
- Eighth Act amending the Road Traffic Act
- Action plan to create ethic rules for self-driving computers
- Reform of the EU Regulations on Reducing CO_2 Emissions of new Passenger Vehicles and light commercial vehicles
- EU Regulation to reduce CO_2 emissions of heavy-duty vehicles (HDV)
- EU Regulation on national GHG reduction contributions for sectors outside the scope of the ETS (non-ETS) in the 2021–2030 period (see Chapter 3.1)
- Climate change mitigation laws
- Creation of a commission and drafting a strategy for the "Future of Affordable and Sustainable Mobility"

Electric mobility – alternative fuels – refilling and charging infrastructure

- Electric Mobility Market Incentive Package
- Local Electric Mobility funding programme
- Charging Infrastructure Ordinance I, II and III
- Regulations on Minimum Technical Requirements for the Safe and Interoperable Deployment and Operation of Publicly Accessible Electric Vehicle Recharging Points
- Charging Infrastructure Funding Guidelines
- "Renewable and Mobile" funding programme
- Second Act amending the Energy Tax Act and the Electricity Tax Act
- Round Table on Gas-based Mobility
- Maritime Technologies of the Next Generation R&D programme
- Taskforce on LNG in Heavy-duty Vehicles
- H2 Mobility project
- Clean Air 2017–2020 immediate action programme

Shift to environmentally-friendly modes of transport

- Promotion of investment in the rail infrastructure
- 2020 National Cycling Plan
- 2030 Federal Transport Infrastructure Plan
- Clean Air 2017–2020 immediate action programme
- Federal programme: Hydrogen and Fuel Cells Technology 2016-2026 – from market preparation to competitive manufacturing processes
- Funding for intermodal transport
- Shifting city/metropolitan traffic to rails – Improving air quality in cities

8 Greenhouse gas emissions

Where do we stand?

The amount of greenhouse emissions went down by 23.7% between 1990 and 2016. However, they went up again slightly over the previous year. The greatest increase was in transport sector emissions, which is due in particular to growing transport demand as a result of strong economic growth.

In light of the outcome of the Paris Convention on Climate Change (see Chapter 3), the Federal Government adopted a national 2050 Climate Action Plan in November 2016. For the first time, it defines target corridors for emissions reduction in individual sectors by 2030. These will undergo a comprehensive impact assessment and then be discussed with the social partners. If necessary, adjustments can be made to the sectoral targets in 2018. These sector goals are also in line with the corresponding EU targets. The Federal Government is working on a 2030 Programme of measures that should ensure that the 2030 targets will be reached.

What is new?

The Federal Government will continue to implement the 2020 Climate Action Programme, assess its effects on lowering emissions, and determine what additional action should be taken in order to reach the climate protection goal for 2020 (40% less greenhouse gases compared with 1990) set forth in the coalition agreement between the CDU, CSU and SPD. Greenhouse emissions must for example be reduced over a period of four years by the amount generated in the transport sector in one year.

The Federal Government set up the “Growth, Structural change and Jobs Commission” in June 2018, which is tasked with presenting specific recommendations on the topics specified in the resolution which created this commission. One important task is to draft a programme of action with the focus on the areas specified in the resolution.

	2016	2020	2030	2040	2050
Greenhouse gas emissions					
Greenhouse gas emissions (compared with 1990)	-27.3%*	at least -40%	at least -55%	at least -70%	largely greenhouse-gas-neutral -80 to -95%

* Provisional figure for 2016

8.1 Total greenhouse gas emissions

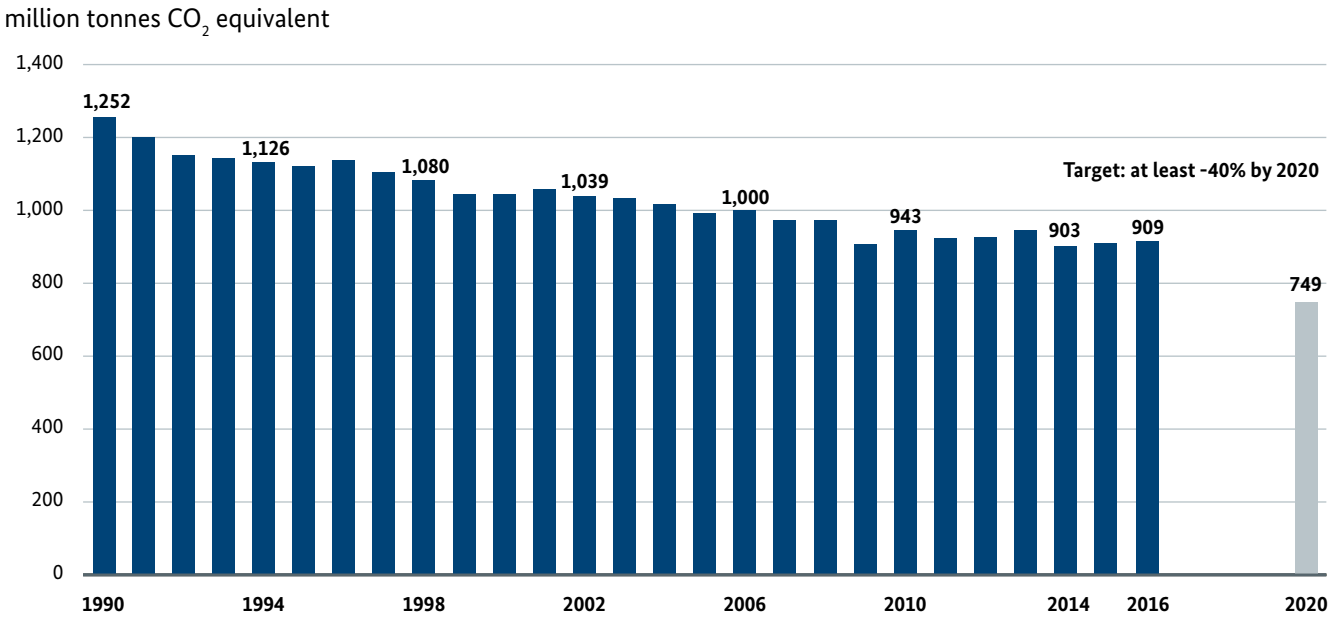
According to 2016 estimates of the Federal Environment Agency, total greenhouse gas emissions in Germany have fallen by 27.3%, or a total of 342 million tonnes of CO_2 equivalent, since 1990. Approximately 909 million tonnes of greenhouse gases were emitted, which corresponds to one-fifth of the annual greenhouse gases produced by the European Union. The increase since 2015 is about 3 million tonnes. The energy industry is the largest emitter in 2016, with 37% of total emissions. The second-biggest emitter were the energetic and process-related emissions produced by industry at 21%, followed by transportation (18%) and private households (10%). Agriculture contributed over 7% to total emissions. The remaining 7% were emitted by other combustion plants and to a small degree, by the waste and waste water sectors as well as fuel collecting and distribution. According to preliminary calculations, greenhouse emissions dropped by about 0.5% in 2017 compared to the previous year (compared with 1990: -27.7%). The significant reduction in emissions from the energy sector made a major contribution, at 4.1%. It should be noted that the aforementioned figures for the various sectors do not completely reflect the categories of the 2050 Climate Action Plan. These figures are therefore not comparable.

The reduction of greenhouse emissions in Germany is anchored in a European framework. The EU has committed to reducing emissions by 20% by 2020, compared with 1990. Whereas the EU countries aim to achieve joint goals for the energy sector and industry with the emissions trading scheme ETS, the reduction targets for the remaining sectors – transport, buildings, agriculture and waste are divided into national targets for each Member State. In the current effort sharing framework, Germany agreed to reduce its emissions in these sectors by 14% compared with 2005 by 2020. To achieve this target, ambitious national measures are much needed (see Chapter 3).

Emissions in the energy sector fell slightly compared with the previous year. In contrast, households and transport had significantly higher emissions than the year before. Emissions in the transport sector went up the most, with an increase of 4 million tonnes over 2015, or 2.5%. The increase in transport emissions is primarily due to the fact that road haulage increased by 2.8% and passenger car traffic by 2%. Private households were affected by the relatively cool weather and also leap day. Temperature trends and the corresponding higher demand for heating led to an increase in emissions of households and other small consumers of 3.6 million tonnes (+4.1%). The greenhouse gas emissions of the energy sector dropped by 1.4%.

Diagram 8.1: Meeting the target for greenhouse gas emissions in Germany

2020 target	Reduction in greenhouse gas emissions of at least 40% (compared with 1990)
Status in 2016	-27.3%



Source: Working Group on Energy Balances, 12/2017

Trend	●●●○○
Measures	2020 Climate Action Programme

The emissions of the energy sector have also declined appreciably over the long term. In 2016, emissions were around 22% below 1990 levels and therefore just clearly below the overall reduction achieved. This was due, inter alia, to the increasing importance of the use of renewables (see Chapter 4) and their substitution of fossil-based energy, and to better plant efficiency.

Weather conditions, low commodity prices and a high electricity export surplus had a major bearing on the climate footprint for 2016. Colder weather conditions compared with the previous year, and a resulting increase in the need for heating energy, coupled with lower fuel prices caused greenhouse gas emissions to creep up slightly in 2016. A high electricity export surplus with a still high proportion of coal-derived electricity, and therefore emissions with a high carbon intensity, also prevented a more significant decline in GHG emissions in the electricity sector, despite the continued expansion of renewable energy.

Of the individual greenhouse gases, CO_2 is the most dominant gas emitted, primarily as a result of combustion. Owing to the above-average decrease in other greenhouse gases, the share of CO_2 emissions has increased by 4 percentage points to roughly 88% since 1990. Methane emissions (CH_4) had approximately a 6% share in 2016, and nitrous oxide (N_2O) 4.2%. Fluorinated greenhouse gases accounted for around 1.7%. This greenhouse gas make-up is typical of a highly industrialised country.

To reach the 40% target, the Federal Government adopted the 2020 Climate Action Programme in December 2014 containing a range of over 100 measures. A climate change mitigation gap determined to be 5–8 percentage points formed the basis of the 2020 Climate Action Programme.

The Federal Government oversees the implementation of the measures in the Climate Action Programme in a continuous process and presents a Climate Change Report each year. This presents current trends in the development of emissions in the various action areas, describes progress in the implementation of the measures contained in the Climate Action Programme and provides an outlook of the expected effect the individual measures will have on reducing emissions by 2020. The first Climate Action Report was presented by the Federal Government in November 2015 (see Chapter 8.4).

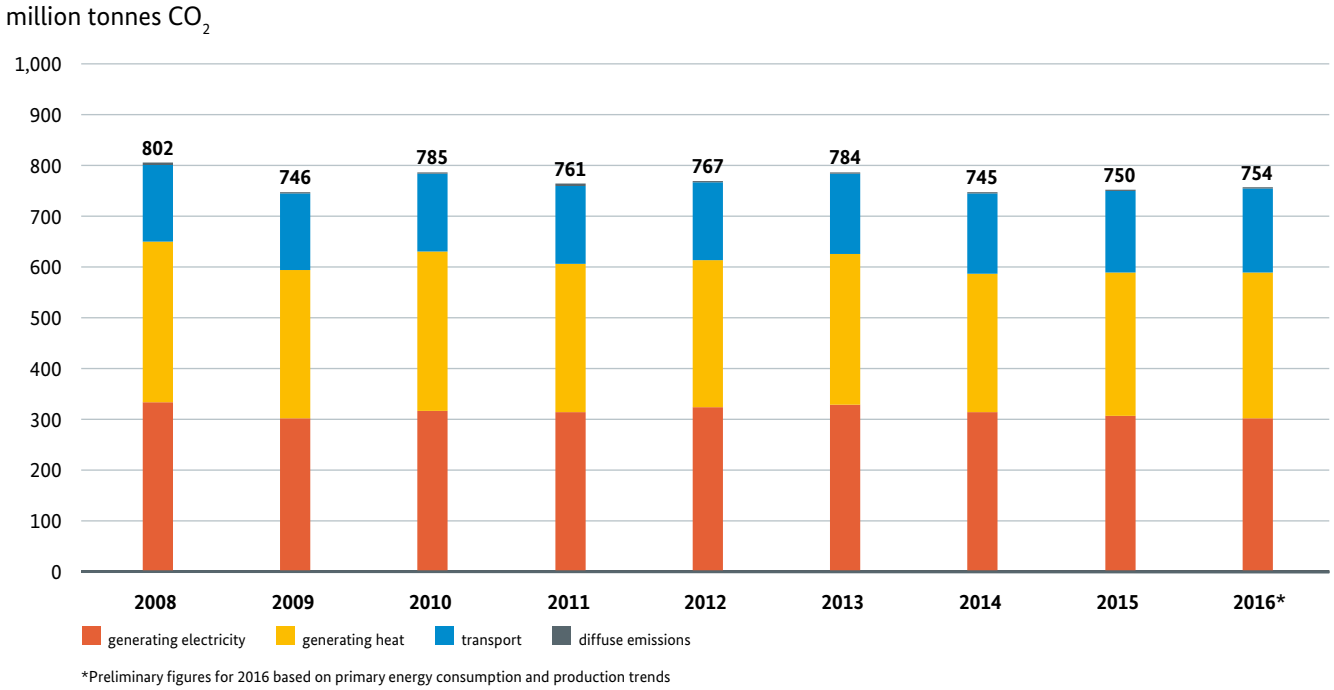
The 2017 Projection Report published in April 2017 investigates two scenarios: The model calculations using the MMS scenario (with measures) include all climate mitigation and energy policy measures in the various sectors that were newly introduced by the end of July 2016 or were significantly modified and implemented or instigated. The second scenario, the MWMS (with additional measures) looks at the effects of additional, already adopted or planned government measures, in particular the measures not yet implemented from the interministerial 2020 Climate Action Programme and the National Action Plan on Energy Efficiency. Projections indicate a minimisation of between 34.7% (MMS) and 35.5% (MWMS) over 1990 levels. Sensitivity analyses also assess the effects of differences in economic growth, demographics or fuel prices on the trend in greenhouse emissions. With a view to these effects, the possible emissions abatement corridor for 2020 ranges between 33.7% (MMS, strong economic growth) and 38.4% (MWMS, lower balance of electricity exports) compared with 1990. While the Federal Government will take the results of the projection report into account in climate policy considerations, it does not use them directly. Since the last Projection Report, various factors such as greater economic output, lower energy prices, greater amount of transport services used and somewhat higher population figures have indicated that a much lower reduction in emissions can be expected for 2020. According to a current study of the Federal Ministry for the Environment, reduction of greenhouse emissions compared with 1990 will only reach around 32% if no other climate change mitigation measures are taken.

The 2050 Climate Action Plan provides important orientation for the post-2020 period. The Federal Government adopted this Climate Action Plan in November 2016. The 2050 Climate Action Plan aims to spell out in concrete terms Germany's current 2050 climate change goal and the agreed intermediate goals in light of the Paris Agreement, and back these goals with measures based on comprehensive impact assessments (see Chapter 8.4).

8.2 Energy-related greenhouse gas emissions

Energy-related greenhouse gas emissions once again increased in Germany in 2016 compared to the previous year, by around 3.8 million tonnes of CO_2 equivalent (around 0.5%), to 772 million tonnes of CO_2 equivalent. The energy-related GHG emissions comprise almost 85% of total greenhouse emissions (combustion processes, energy sector, diffuse emissions and additional emissions for trade, heating systems and vehicles). Because however around 98% of these were due to release of carbon dioxide, the following analyses and assessments focus on CO_2. Energy-related CO_2 emissions caused about 96% of total CO_2 emissions (see Diagram 8.3). Just as with the overall CO_2 emissions in Germany, the energy-related CO_2 emissions went up by about 1% over the previous year.

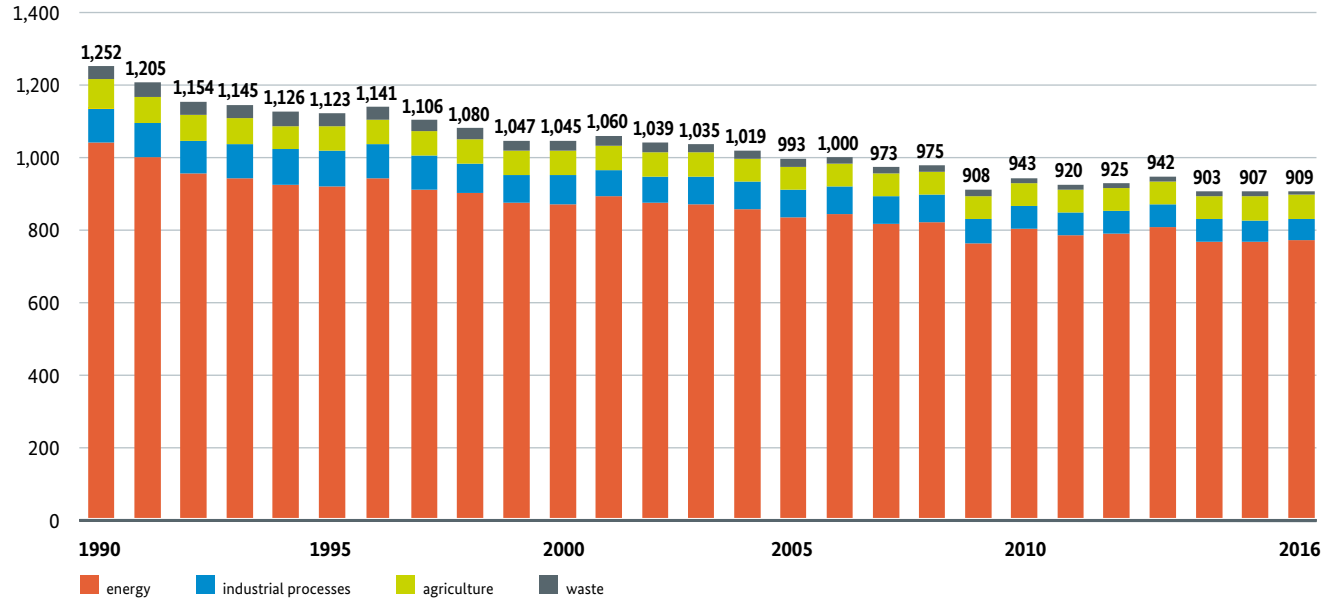
Diagram 8.2: Energy-related CO_2 emissions from the electricity, heating and transport sectors as well as diffuse emissions



Source: Working Group on Energy Balances, 04/2017

Diagram 8.3: Greenhouse gas emissions by source group

million tonnes CO_2 equivalent



Source: Working Group on Energy Balances, 12/2017

Greenhouse gas emissions avoided through the use of renewable energy

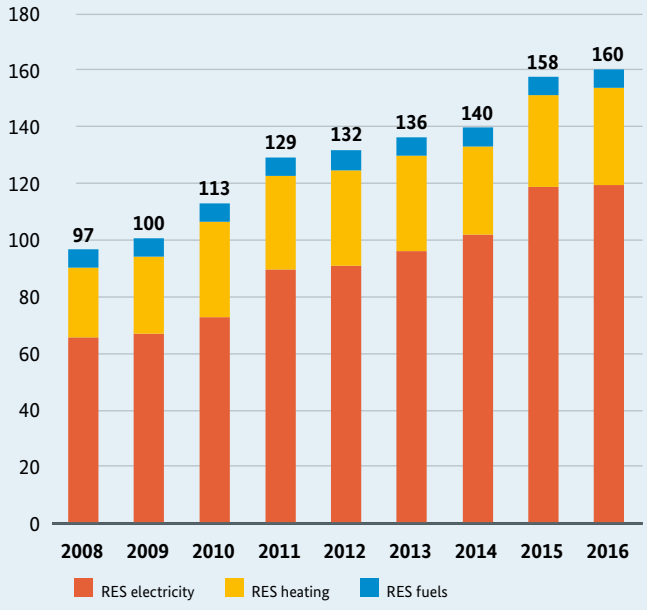
The replacement of fossil fuels with renewables (see Chapter 4) makes a key contribution to reaching the climate goals. Total emissions of around 160 million tonnes of CO_2 equivalent were avoided in 2016, benchmarked against a reference system without renewable energy and with the same demand. The GHG emissions saved correspond to the emissions generated by the road traffic sector in 2016. The electricity supply sector accounted for emissions of 119 million tonnes of CO_2 equivalent. The use of renewable energy sources in the heating sector reduced emissions by 34 million tonnes of CO_2 equivalent, and the use of biogenic fuels, by 7 million tonnes.

Calculations of the volume of emissions avoided through the use of renewable alternatives are based on a net analysis. Here, the emissions produced by the provision of final energy from renewable sources are offset against the gross emissions avoided by substituting fossil fuels and/or nuclear fuels, where applicable, with renewables (UBA 2017a). In contrast to the GHG emissions of GHG inventories that are calculated according to internationally binding rules, this calculation also factors in all the upstream process chains involved in the production and provision of the fuels and for the construction and operation of the plants (excluding plant dismantling).

Biomass helped reduce emissions in 2016 in all sectors of consumption. Roughly 65 million tonnes of CO_2 equivalent – the annual GHG emissions of the agriculture sector – were avoided through the use of biomass in solid, liquid or gas form in all three sectors of consumption. Around 45 million tonnes of CO_2 equivalent were avoided through the use of onshore wind energy, 23 million tonnes of CO_2 equivalent through the use of photovoltaic installations and approximately 16 million tonnes of CO_2 equivalent through the use of hydroelectric plants. In 2017 the drop in emissions may have been about 179 million tonnes of CO_2 equivalent overall.

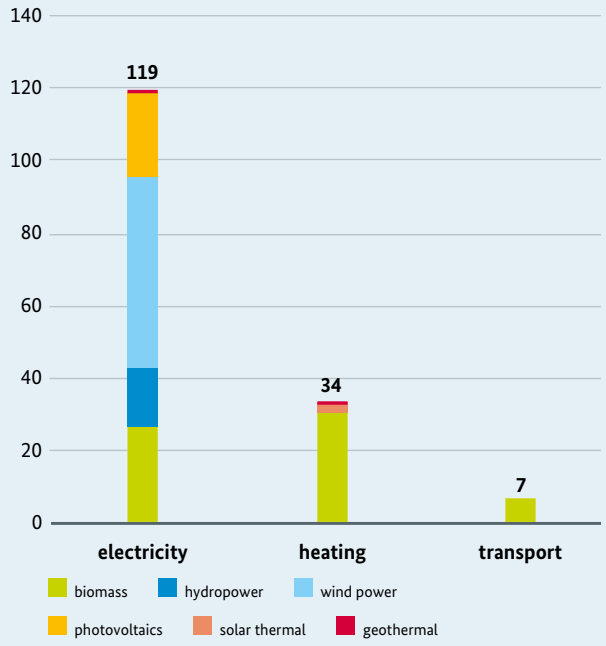
In the electricity and heating sector, the result hinges significantly on the type of fossil or nuclear fuels that are replaced. With regard to the use of biomass for energy purposes, the type and origin of the raw materials used also play an important role in the emissions footprint.

Diagram 8.4: Greenhouse gas emissions avoided through the use of renewable energy
million tonnes CO_2 equivalent



Source: BMWi on the basis of the Working Group on Energy Balances 02/2018*

Diagram 8.5: Effect of renewables on avoidance of emissions in 2016 disaggregated by energy source
million tonnes CO_2 equivalent



Source: BMWi on the basis UBA 2/2018

The methodology (Diagrams 8.4 and 8.5) applied to calculate the emissions avoided by renewables is based on the specifications of the EU Renewable Energy Directive (2009/28/EC).

CO_2 emissions from the energy sector have gone down significantly since 1990. While energy-related CO_2 emissions continue to follow a downwards trend when viewed over the long term, they registered a slight 0.5% increase to 772 million tonnes in 2016 compared with 2015 (see Diagram 8.2), thereby accounting for the bulk of the total 802 million tonnes of CO_2 emissions in 2016.

Most of these energy-related CO_2 emissions were produced from the burning of fossil fuels to generate electricity and heat, and in the transport sector. Overall, the increase in 2016 is primarily attributable to increased emissions in the transport sector and in households and from small consumers. On the other hand, CO_2 emissions from electricity generation dropped by about 5 million tonnes. Other energy-related emissions comprised of diffuse emissions or by line loss remained constant compared with the previous year, at somewhat more than 2 million tonnes of CO_2.

Weather adjusted, CO_2 emissions – the lion's share of energy-related GHGs, ranged above actual emissions. According to calculations made by the Federal Environment Agency on the basis of DIW figures (1995), temperature-adjusted energy-related CO_2 emissions (combustion of fossil fuels and diffuse emissions, source groups 1A and 1B) in 2016 were at 765.3 million tonnes (2015: 762.6 mt), thereby exceeding actual emissions of 751.7 million tonnes in 2016 (2015: 747.5 mt). The weather-adjusted figure is only mentioned here for information and has no relevance for targets, because they are calculated on the basis of actual emissions.

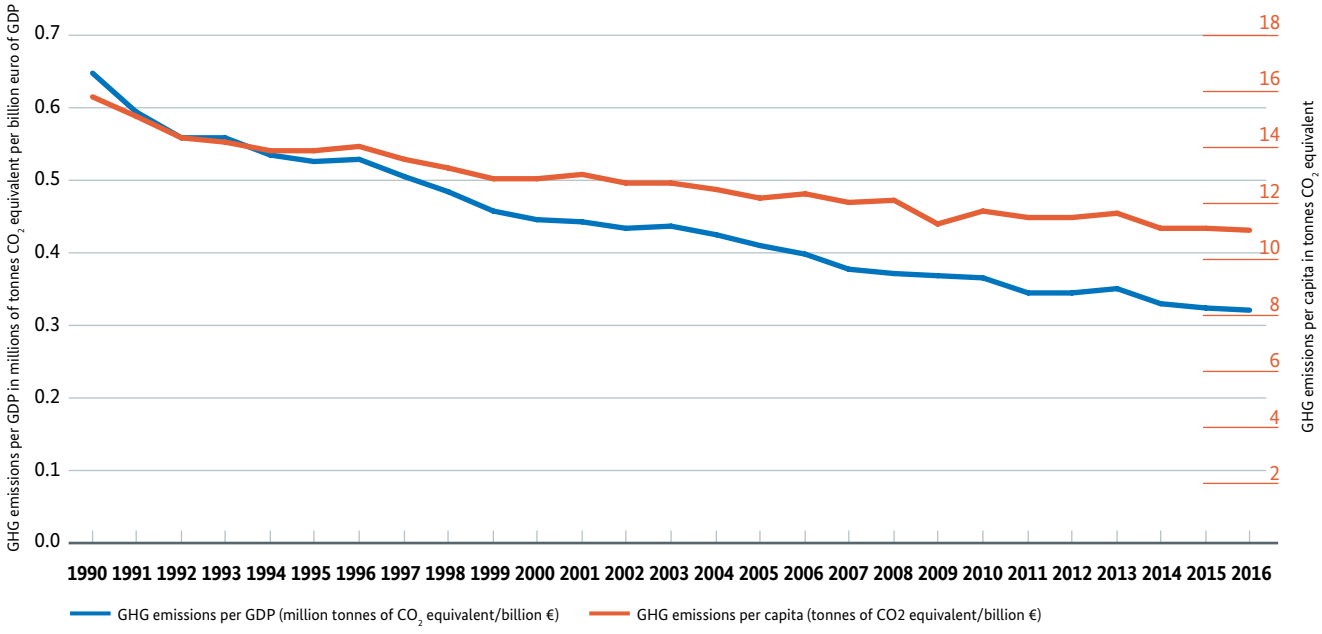
8.3 Greenhouse gas emissions and economic output

Overall, greenhouse gas emissions in relation to economic output have continued to decrease. While greenhouse gases amounting to around 0.65 million tonnes of CO_2 equivalent were emitted per billion euro of GDP in 1990, this figure had dropped to just 0.37 million tonnes of CO_2 equivalent in 2016. This translates to a 65% decrease. Specific greenhouse gas emissions per capita also dropped by 28% between 1990 and 2016, going from 15.7 tonnes to 11.3 tonnes of CO_2 equivalent (see Diagram 8.6). In the EU-28, specific greenhouse gas emissions per capita fell by 25.5% between 1991 and 2015, from 11.72 to 8.45 tonnes of CO_2 equivalent.

8.4 2020 Climate Action Programme and 2050 Climate Action Plan

The 2020 Climate Action Programme is the central instrument to make up the difference identified in the 2013 Projection Report between current figures and 2020 targets. The Action Programme is designed to contribute between 62 and 78 million tonnes of CO_2 equivalent toward reaching the climate change target. This aggregate contribution is based on contributions from more than 110 individual measures.

Diagram 8.6: Greenhouse gas emissions per capita and GDP



Source: UBA, Federal Statistical Office 12/2017

The quantification to assess the impact of measures to reduce emissions, as illustrated in the 2017 Climate Action Report, was performed by a group of experts on behalf of the Federal Ministry for the Environment. It shows that the measures of the Action Plan are effective, and that a substantial contribution can be expected toward reaching the climate change goal as quickly as possible. However, the current assessment also shows that the total projected effect of the individual measures in the amount of 40 to 52 million tonnes of CO_2 equivalent for 2020 ranges below the figure for 2014 (see Table 8.1). This estimate is however subject to uncertainties regarding assumptions and effects.

Table 8.1: Contribution of central policy measures to reaching the 40% target

	Contribution to GHG emissions reduction in 2020 in million tonnes of CO_2 equivalent	
Central policy measures	**Contribution according to original estimate as at December 2014**	**Contribution according to current expert assessment (rounded figures)**
National Action Plan on Energy Efficiency (NAPE) excluding measures in the transport sector	approx. 25–30 (including Efficiency Strategy for Buildings)	19–26 (including Efficiency Strategy for Buildings)
Climate-friendly Building and Housing strategy and federal, state and municipal energy-related renovation road maps	Approx. 5.7–10 in total (1.5 - 4.7 of which in addition to NAPE)	3.2 to 3.8 in total (0.8 of which in addition to NAPE)
Measures in the **transport sector**	approx. 7–10	1.1–2
Reduction in non-energy-related emissions in the sectors:		
Industry, trade, commerce and services	2.5–5,2	1.3–1,8
Waste management	0.5–2.5	0.16
Agriculture*	3.6	0.6–2.2
Reform of the emissions trading system	Effects of most recent reforms are not included here	
Additional measures, particularly in the electricity sector	22	16.4–18.4
Advice, information and independent initiatives for more climate action		0.48
Total	**62–78**	**40–58**

Source: 2017 Climate Action Report
*)The contributions to GHG emissions reduction estimated in December 2014 are based on the emission factors for nitrous oxide valid at that time for international reporting. These have since been adjusted and form the basis for estimates in the 2016 Climate Action Report.

In particular, there is often no empirical basis for quantification of newly introduced measures. For this reason, the Federal Government does espouse evaluating the individual contributions of the measures. Furthermore, there are additional ongoing and planned studies that will be taken into account in future assessments. The Federal Government will continue to implement these measures and evaluate their effects on lowering emissions. However, it is not likely that the measures will deliver the desired reductions by 2020. According to a current study of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the programs implemented up to now can be expected to reduce greenhouse gas emissions by around 32% compared with 1990. This would create a gap of about 8 percentage points.

The Federal Government therefore reaffirms the need for consistent implementation of the agreed measures in order to actually meet the reduction targets it adopted for the measures in the 2020 Climate Action Programme. The coalition agreement between the CDU, CSU and SPD also provides for additional action to close the gap to the 2020 climate goal as quickly as possible. Furthermore, the Federal Government is preparing a 2030 Programme of Measures for the 2050 Climate Action Plan.

The 2050 Climate Action Plan adopted by the Federal Government in November 2016 is based on the outcome of the 21st Framework Convention on Climate Change and is being implemented as a modernisation strategy on three levels: It develops concrete guiding principles for the individual action areas for 2050, allows room for innovation and strives for maximum sustainability. For all action areas it maps out robust, transformative paths, highlights critical path dependencies and pinpoints interdependencies. In particular, it defines concrete milestones and strategic measures for the GHG intermediate goal for 2030, also taking impact and cost analyses into account. The Federal Government is working on a 2030 Programme of measures.

Transparency and participation: Climate Action Alliance

With the adoption of the 2020 Climate Action Programme, the Federal Government set up a Climate Action Alliance, overseen by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The task of the Climate Action Alliance is to support implementation of the measures adopted under the Climate Action Programme, make it easier to realise potential that is currently rated as "not yet quantifiable" and identify additional possibilities for action. The Climate Action Alliance met for the first time in March 2015 and has since then convened twice a year, once in spring and once in autumn. A range of issues have been discussed at the sessions so far, including climate action in the transport sector, in municipalities, agriculture, small and medium-sized enterprises, the craft sector and industry.

Central measures of climate change mitigation

- Measures for reaching the 40% target (see Table 8.1)
- 2050 Climate Action Plan and the planned 2030 Programme of Measures (see Chapter 8.4)

Part II: TARGETS AND POLICIES OF THE ENERGY TRANSITION

This part of the Monitoring Report looks at other targets and the energy policy framework for the implementation of the energy transition. Specifically, this part addresses the following topics:

Power plants and security of supply

Affordable energy and a level playing field

Environmental compatibility of the energy supply system

Grid infrastructure

Integrated development of the energy system

Energy research and innovation

Investment, growth and jobs

9 Power plants and security of supply

Where do we stand?

Germany's electricity supply is secure. There is enough energy to cover demand in Germany at all times, guaranteeing a high level of supply security.

There has been another strong increase in installed renewable capacity. Renewable energy covers about half of the power plant capacity.

The Electricity Market Act that entered into force in July 2016 has upgraded the electricity market to an Electricity Market 2.0.

The Electricity Market Act has also enhanced monitoring of supply security in the electricity market.

What is new?

Block B of the Gundremmingen nuclear power plant was shut down in late 2017 – an additional step toward the exit from nuclear power.

SMARD, an information platform, went online in July 2017, and provides updated and easily understandable electricity market data, thereby enhancing transparency in the electricity market. The core energy market data register is planned to go into operation in December 2018.

Security of supply	Efficiently covering Germany's energy needs at all times.
Nuclear phase-out	Switching off the last nuclear power plants by the end of 2022.

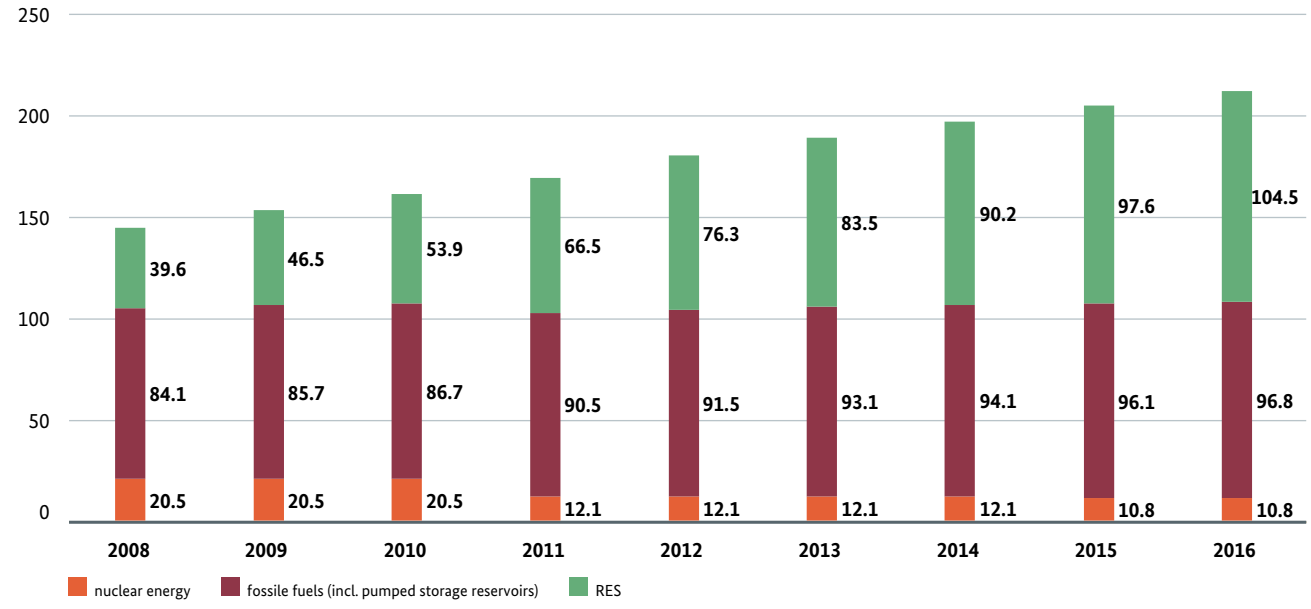
9.1 Power plants

Installed renewable capacity showed strong growth again in 2016. Overall, the net nominal capacity of the electricity generation plants connected to the German power grid grew by about 68 GW between 2008 and 2016 (see Diagram 9.1). In 2016, the nominal capacity of electricity generation plants based on renewable energy amounted to 105 GW, up 7% on the previous year. The largest growth came from wind power. The share of nominal capacity from renewables rose to over 49% of total power plant capacity (see also Chapter 4). As the supply of energy depends on natural conditions – particularly in the case of wind and solar – and the full installed capacity can therefore not always be accessed, significantly more capacity is needed to produce a certain amount of electricity when using wind energy and photovoltaic installations than with the conventional power station fleet. Installed capacity alone is therefore not an indicator of security of supply. The latter is discussed in greater detail in Chapter 9.2.

While in some Länder, conventional power plants primarily feed into the grid, renewable energy dominates in nine Länder (see Diagram 9.2). Nuclear power plants currently still contribute to electricity generation in four *Länder*. In addition, foreign electricity generation facilities with a net nominal capacity of around 4.6 GW are also connected to the German grid. Bavaria and Lower Saxony are the main hubs of installed capacity based on renewables, while North Rhine Westphalia leads the way for conventional power plants. The highest share of renewable energy, measured against total installed capacity, can be found in the states of Mecklenburg-Western Pomerania (85%), Saxony-Anhalt (76%), Schleswig-Holstein (75%) and Rhineland-Palatinate (73%). The share of conventional power stations in the installed capacity is highest in the city states of Berlin, Hamburg (both 93%) and Bremen (85%).

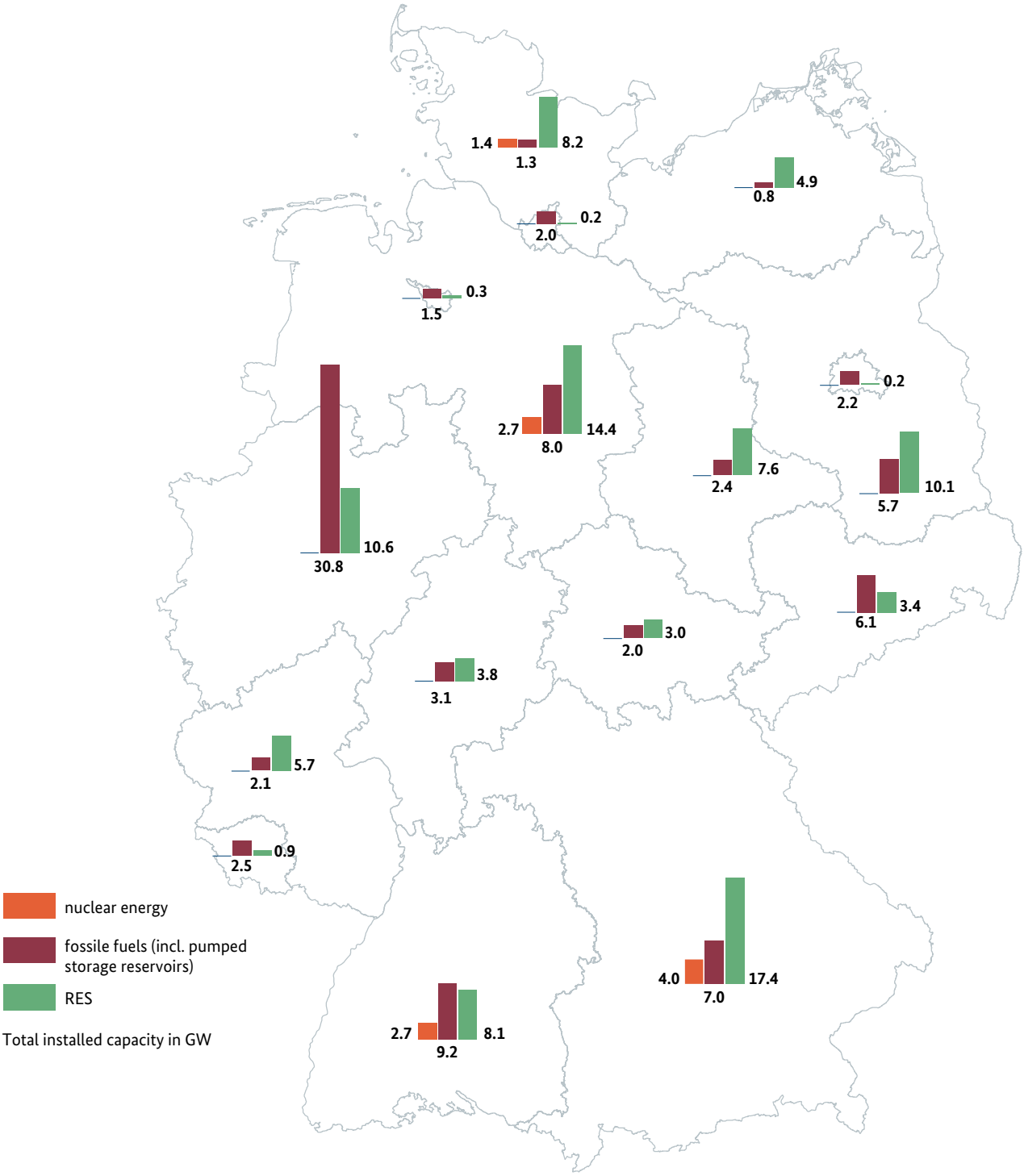
Combined heat and power (CHP) is an important component of the energy transition, and plays a special role in conventional electricity generation and local heating supply. By means of simultaneous generation of electrical energy and heat (e.g. for district heating), CHP plants use fuel more efficiently than production in separate plants. This conserves resources and is good for the climate and the environment. The goal of the Combined Heat and Power Act (CHPA) is to expand CHP. This act therefore envisions expanding power generation to 110 TWh in 2020 and 120 TWh in 2025. In fact, CHP electricity generation was already at 117.1 TWh in 2016 – an increase of 11% over the previous year. Heat generation grew by about 5% to 224.1 TWh (Working Group on Energy Balances 2017), meaning that the 2020 goal was achieved four years early, and was even exceeded. The goal for 2025 will most likely also be achieved. This expanding the use of CHP has been successful. Further development of CHP will focus on reducing its CO_2 emissions and making it more flexible to ensure its future in the energy transition. The coalition agreement between the CDU, CSU and SPD also includes this goal.

Diagram 9.1: Installed capacity of the electricity generation plants connected to the German power grid
in GW



Source: Federal Network Agency, November 2017
Numbers refer to nominal capacity.

Diagram 9.2: Distribution of total power plant capacity among the Länder



Source: Federal Network Agency, November 2017

Pumped-storage power stations are a well-established, large-scale form of storage. In 2016, pumped-storage power stations with a net nominal capacity of 9.4 GW were connected to the German grid, including pumped-storage power stations in Luxembourg and Austria with a combined capacity of around 3.1 GW. Construction is currently underway on new facilities with a capacity of 372 MW, which will feed into the German grid from Austria.

In the period 2017–2020 the existing overcapacity in conventional power plant capacity will probably be reduced somewhat. The total capacity of conventional power generation plants hardly changed over the previous year, but a slight decrease in black coal energy was balanced out with an increase in gas. According to the Federal Network Agency, new conventional power plant capacity added during this time will amount to around 2.3 GW of net nominal capacity

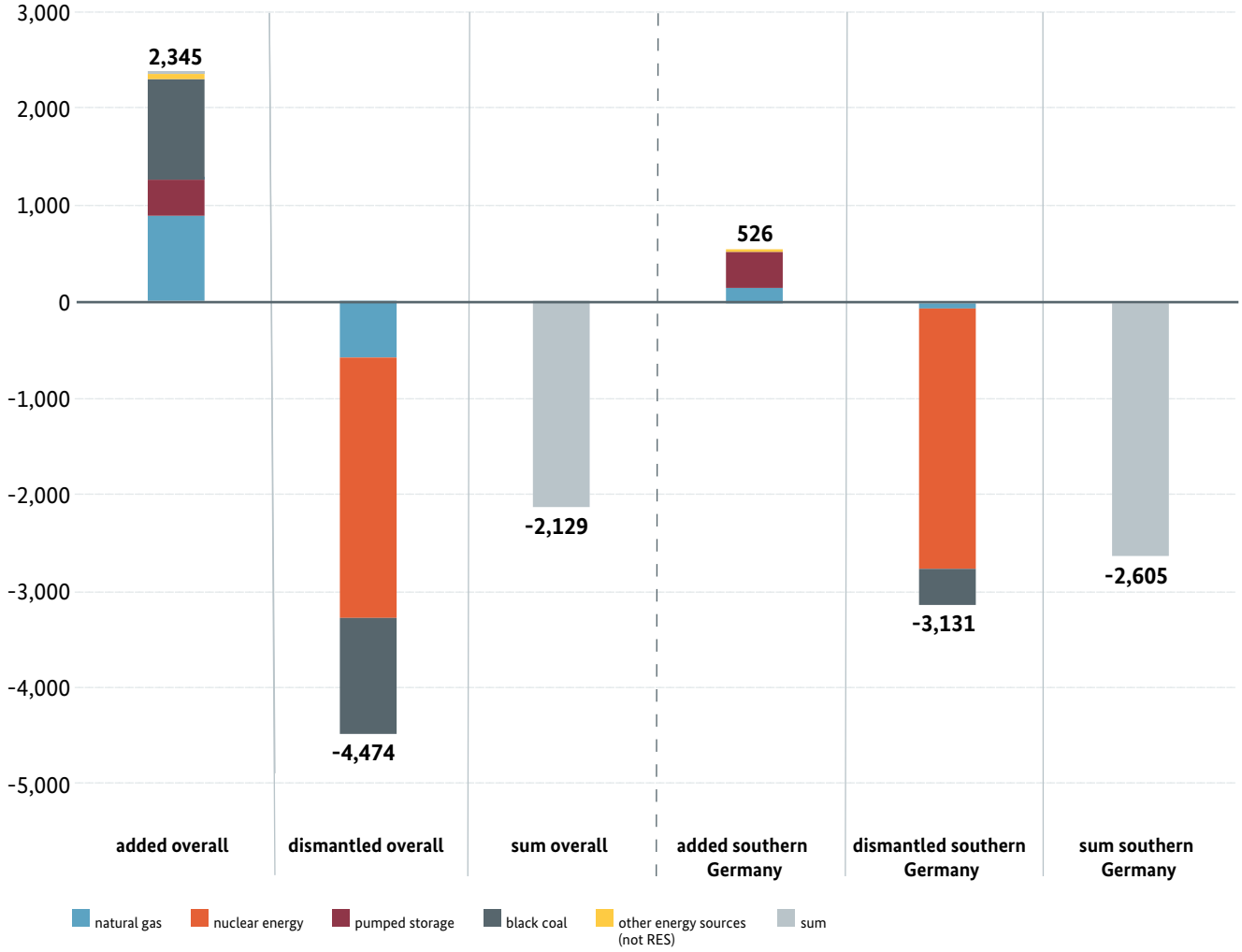
Transparency and participation: easy access to all data and information related to the energy market

SMARD is a new energy information platform that went online in July 2017 to increase transparency in the electricity market. At https://www.smard.de/en/5790, key data for the German electricity market and some for other European markets can be accessed in real time, presented in graphics and downloaded. It is possible to look up data on generation, consumption, wholesale prices, imports and exports, as well as data on balancing energy, for differing time periods and in graphic form.

SMARD speaks to citizens interested in the energy transition and the electricity market, as well as experts from the energy sector, in companies and the research community. This platform provides easy access to information and contributes to a more informed debate on energy transition and the electricity market.

The **Core energy market data register** will also provide more transparency for the electricity market. The Core Energy Market Data Register Ordinance entered into force in July 2017 Starting in 2017, the Register will merge the master data of all the plants in grid-bound energy supply in Germany's electricity and gas market, and the master data of market stakeholders, to create a single online database. Reporting obligations will be simplified and reduced. Register data will also be published on SMARD. The Federal Network Agency plans to implement the Register in December 2018.

Diagram 9.3: Conventional generation capacities (including pumped storage reservoirs): projections for new capacity added and dismantled capacity in the period from 2017 to 2020, in all of Germany and in southern Germany
in MW



Source: Federal Network Agency, November 2017
The data for decommissioning take into account power plants that will be permanently shut down according to closure notification pursuant to Section 13a of the Energy Industry Act (old version) and Section 13b of the Energy Industry Act, as well as nuclear power plants. Numbers refer to nominal capacity.

nationwide. On the other hand, 4.5 GW of conventional power plant capacity that will be shut down, primarily in the area of nuclear energy (see Chapter 9.3). Moreover, on balance, natural gas and pumped storage saw slight growth, whereas black coal capacity dropped slightly. More than two-thirds of dismantled capacity took place in Southern Germany, whereby only somewhat more than one-fifth of the added capacity took place there (see Diagram 9.3).

By October 2019, 13% of lignite capacity will be put on security standby. Under the Electricity Market Act, lignite-fired power plant units with a capacity of 2.7 GW will gradually go off-line. Before being shut down permanently, the plants will first be transferred to a security standby reserve for a period of four years; this reserve can be called upon as a very last resort to help secure the electricity supply in the case of emergencies. Three of the power generation units planned for security standby had already been temporarily shut down.

The security standby reserve should deliver emission reductions of 12.5 million tonnes of CO_2 by 2020. This reduction is an important contribution to climate change mitigation. If this measure does not deliver the desired CO_2 reduction of 12.5 million tonnes, the power plant operators will be required to make additional carbon savings totalling up to 1.5 million tonnes of CO_2 per year from 2019 onwards.

The newest amending legislation of the Combined Heat and Power Act (CHPA) provides incentive for investment in highly efficient, flexible and carbon-reduced power plants. By replacing coal with natural gas and with the moderate construction of new CHP plants, an additional 4 million tonnes of CO_2 are expected to be saved in the electricity sector by 2020. The European Commission in October 2016 approved funding under the CHPA, and in May 2017, the pay-as-you-go system provided by the CHPA. Funding for new and modernised CHP plants with electricity generation

Storage – a contribution to a more flexible electricity system

A continually growing percentage of our electricity will be produced from renewable energy resources in the future. Wind power and photovoltaics will be the mainstay of the electricity supply (see Chapter 4). As the feed-in from both forms of energy varies greatly depending on the weather and time of day, future electricity systems must take this into account and become more flexible. With a high percentage of renewables in the electricity mix, storage systems along with other flexibility options, such as flexible consumers and producers, can contribute to the security of supply (see also the Electricity Market Green Paper by the Federal Ministry for Economic Affairs and Energy). Electricity storage systems can help separate generation from consumption. In addition, they can also provide balancing capacity and thereby help keep the grid frequency stable.

In the short- and medium-term, the energy transition will not depend on the expansion of electricity storage systems. Flexible consumers and peak load power plans, in combination with innovative business models and digitisation (see Chapter 12.2) can even out fluctuations between electricity supply and demand, even with high percentages of renewables in the mix. In addition, storage systems are still sometimes more expensive than other flexibility options. However, in order to satisfy the projected mid- to long-term demand for storage, the Federal Government has already started funding development of technologies for finding cost-cutting potential with the Energy Storage Research Initiative (see Chapter 3).

Battery storage units, pumped storage reservoirs, compressed air energy storage and power-to-x such as power-to-gas are important storage technologies. In the case of power-to-x products, renewable energy electricity is used to produce hydrogen or methane which can then either be used directly or can be converted back to electricity. Power-to-gas has the advantage of the capability to store energy over a long period of time and in large amounts. In addition, existing infrastructure – the gas network and underground gas storage can be used.

Under the Energy Industry Act and the Renewable Energy Sources Act, inter alia, electricity storage systems are categorised as a final consumer with regard to offtake, and are therefore basically subject to corresponding payment obligations. However, in reality, the major portion of storage systems are exempted from this obligation. A prerequisite is that the storage feeds in electricity to the public network. In principle, the use of individual flexibility options should be determined through competition, with efficiency and economic viability decisive factors in this regard.

In previous years, the primary balancing power market has received increased attention in the area of large battery storage systems. According to information from the sector, by late 2017 almost 180 MW of overall capacity had been installed in Germany. Battery storage probably accounted for about 25% of the share in the market for primary control power.

of more than 1 MW and up to 50 MW was opened up for bidding in 2017. The Public Tender Ordinance for this funding entered into force in August 2017. In addition to CHP plants, a new funding category will be added in 2018 for innovative CHP systems. These systems combine especially flexible CHP plants with renewable heat, for example sourced from solar thermal power plants or heat pumps. New, modernised or refitted CHP plants with electrical generating capacity of up to 1 MW or more than 50 MW are still eligible for the approved funding.

9.2 Supply security

Supply security means that demand for power can be met at any time. In addition to having sufficient energy generation capacity, a functioning electricity market is also essential, as well as efficient transport of electricity from power plants to consumers. The Federal Ministry for Economic Affairs and Energy regularly publishes (at least every two years) a comprehensive report on security of supply that reviews this topic on a broad scale and takes a number of sub-topics into account (BMWi 2016b). The next report will appear in 2018. This chapter will provide an overview of the most important aspects and results.

Supply security on the electricity market is still at a high level – supply and demand are always in balance on the market. Various studies conducted between 2015 and 2018 for the period 2015-2025 reveal that the electricity market in Germany and neighbouring countries can – with reference to Germany – consistently balance demand and generation with a very high probability of almost 100% (Amprion et al. 2018, Consentec u. r2b Energy Consulting 2015, ENTSO-E 2017). These studies look at the security of supply on the electricity market across national borders and evaluate the them in comparison to the state of the art. Furthermore, these studies show that Germany also has a very high level of supply security when compared with other countries, making the German power supply system one of the most secure systems in the world.

Germany has many power plants, storage facilities and controllable renewable energy resources that can produce energy on demand, at any time. In addition, some companies can to a certain extent lower or postpone their energy demand. They adapt their demand to market prices, as they do with other production factors (e.g. raw materials). Because a large supply of renewables usually leads to low electricity prices, companies with flexible consumption can profit from this. This also applies to storage systems that can accordingly be charged at reasonable cost.

The regulations on the electricity market that were adapted to the Electricity Market Act that entered into force in July 2016 also help to enhance supply security. They enable market participants to prepare better for times of fluctuating renewable energy resources. One component is the binding obligation of all electricity dealers (called balancing groups) to ensure customer demand at all times and to take requisite precautions. Otherwise they will be subject to significant fines. This provides substantial pressure to always keep the balancing group evened out (also see Chapter 9.4).

The electricity supply is backed up in several ways. Next to a reserve for regional risks in the transmission systems (grid reserve), even today there is already what is called a security standby available in the electricity market for longer-term risks. In order to satisfy electricity demand at all times, as of October 2019 there will also be a capacity reserve for any short-term extreme events on the electricity market.

Monitoring of security of supply in the electricity is being continually enhanced. When the Electricity Market Act came into force in 2016, the previous report on the German capacity balance was replaced by a method that further develops the requirements to be met by supply security on the electricity market. The new method reflects the incorporation of the German electricity system into the European internal market in electricity, includes new probability-based analyses and more explicitly reflects the framework of the reformed Electricity Market 2.0. Section 51 of the Energy Industry Act stipulates that the BMWi constantly conduct monitoring of supply security, especially according to these new standards. In addition, the Federal Ministry for Economic Affairs and Energy must cooperate in achieving a joint supply security report with neighbouring EU countries.

Supply of natural gas

With annual consumption of 95 billion cubic metres, Germany is the biggest market for natural gas in the European Union and also a key gas transit country. As an interim technology on our transition from fossil fuels to renewables, in particular, natural gas can also continue to play an important role. Germany imports around 92% of its annual gas consumption primarily from Russia, Norway and the Netherlands. Compared with electricity, natural gas can be stored in large quantities. With an effective natural gas storage volume of over 24 billion cubic meters, Germany has the largest storage capacities in the EU. The expansion of the national natural gas infrastructure in line with market needs is guaranteed by the Gas Network Development Plan of the gas transmission system operators (TSO). It is a key component towards maintaining security of supply. The currently binding 2016–2026 Gas Network Development Plan makes provisions for 823 km of new pipeline construction and additional compressor capacity of 429 MW by 2026. Investment for this is budgeted at around €3.9 billion.

In short, the extensive natural gas network, liquid trading markets, the large storage volume and the diversified portfolio of supplier countries and import infrastructures offers Germany's gas consumers a very high level of supply security. Added to this is the good technical status of the natural gas infrastructure, which is reflected in the SAIDI-gas (System Average Interruption Duration Index). This index was at 1.03 in 2016. More information about the supply of natural gas in Germany is provided in the Annual Report on Natural Gas Supply Security published by the Federal Ministry for Economic Affairs and Energy (BMWi 2017a).

The amended Gas Network Access Ordinance that entered into force in August 2017 optimised the gas network access system and adapted it to the new energy sector circumstances that had changed in recent years.

The Act amending the Gas Supply Security Regulation (EU) 2017/1938 expands the options for ensuring an uninterrupted supply of gas for customers in all of the European Union. The key principles set forth in the Regulation form the basis for cooperation on crisis prevention and mutual support and solidarity among the Member States in the event of gas supply crises. Member States must add regional aspects to their risk assessments, prevention and emergency planning and conclude bilateral agreements to act with solidarity regarding gas deliveries in a crisis.

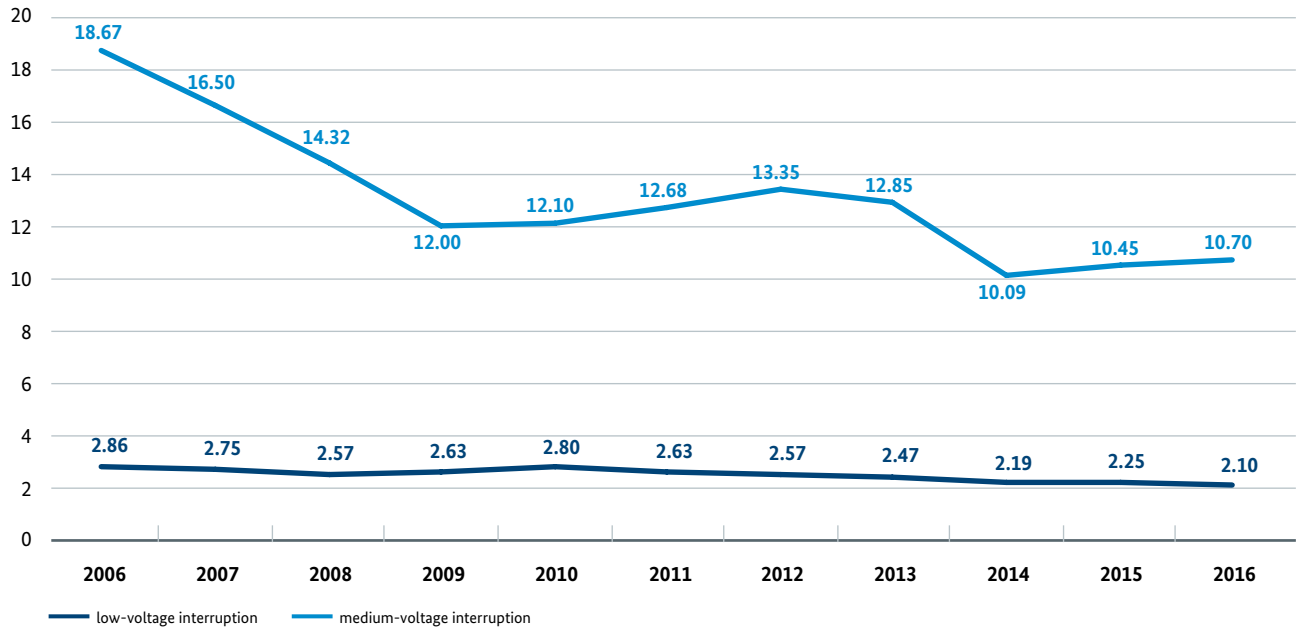
In 2016 the Federal Ministry for Economic Affairs and Energy commissioned a research project titled "Definition and Monitoring of Supply Security in European Energy Markets 2017–2019". The researchers will define reliable indicators and thresholds that help monitor and assess the security of supply in the electricity market. The thresholds should provide guidance on when security of supply should be evaluated and appropriate action taken, by determining minimum standards for indicators. To determine thresholds, costs for new gas turbines in particular will be compared with the costs of a temporary and geographically limited shortfall in electricity, leading to short supply.

Supply security will also be ensured at the European level. Germany is embedded in the European electricity market. The German electricity market is closely connected to the electricity markets of its "energy neighbours", meaning its geographical neighbours as well as Sweden, and in the future, Norway. By taking advantage of smoothing effects across a large area, particularly in the event of peak loads and the feed-in of renewable energy, less energy overall will be required than would be in an isolated energy market without efficient connections to neighbouring countries. Peak demand and lack of wind does not however happen everywhere at once. Supply security can be achieved at a lower cost in the European internal market (see Chapter 3.1). A cross-border perspective and probability-based assessment of supply security are also important elements of the EU Commission recommendation for a future framework for the internal electricity market (EU Commission 2016). This recommendation for the continued development of the European legal framework is currently under negotiation.

The energy supply is also secure for the electricity grid. The secure availability of sufficient transmission and distribution network capacity is a precondition for supplying consumers. To ensure grid stability at the transmission level despite the lags in grid expansion, grid operators must increasingly apply measures to ensure system stability (see Chapter 12.4).

The duration of power interruption at the distribution grid level has remained at a consistently low level, even under international standards. Each year, the Federal Network Agency publishes the System Average Interruption Duration Index (SAIDI), which reports on the average outage duration per connected final consumer at the distribution grid level. The SAIDI value includes all interruptions lasting longer than three minutes. The index stood at 12.80 minutes in 2016, close to the previous year's level. Viewed over the long term, the interruption duration has been continually shrinking. The SAIDI index has dropped since 2006 by over

Diagram 9.4: Development of the SAIDI index
in minutes



Source: Federal Network Agency, 9/2017

40%. Compared with other countries, Germany also ranks among the best internationally.

9.3 Nuclear energy phase-out

Block B of the Gundremmingen nuclear power plant was shut down in late 2017 – an additional step toward the exit from nuclear power. The remaining seven nuclear power plants with a net generation capacity of 9.5 GW will go offline gradually by the end of 2022 at the latest (see Table 9.1).

The funding for long-term costs of nuclear shutdown are available – solving one of the major challenges arising from the nuclear phase-out. On 3 July 2017 German nuclear power plant operators contributed a total of €24.1 billion to the fund for financing nuclear waste disposal by paying deposits to the accounts at German Federal Bank. This ends their responsibility for nuclear waste disposal in the area of interim and final storage. The responsibility for management and financing of interim and final storage was transferred to the Federal Government as soon as all payments were received. However, the companies still have complete responsibility for decommissioning and dismantling of nuclear power plants, as well as for properly packaging radioactive waste and for the financing of these activities. Combining operational obligations with financial responsibility for the operators is regulated by the Draft Act on the Redistribution of Responsibility for Nuclear Waste Management that entered into force in June 2017. The fund invests the money it receives in long-term investments to finance the costs of interim and final disposal in the long term.

The recommendations of the Commission for the Permanent Disposal of High-level Radioactive Waste provide strategies for the search for a final repository. The main focus of these recommendations is a multi-stage, transparent, open-ended and science-based process for finding a final repository. This is defined in the Repository Site Selection Act. and was made more specific with the amendment of 2017. The most important recommendations of the Commission are as follows: All three potential host rocks in Germany will be considered and the Gorleben site will be included in the comparative selection procedure. The final disposal of the waste should be in deep geological formations with the option of reversibility and the retrieval and recovery of the waste. The selection criteria are to be applied in a three-stage selection process to identify the site that offers the best possible safety for a period of one million years. The public should be involved in all stages.

Table 9.1: Schedule for the phase-out of nuclear energy used in production of electricity

Name	Shutdown by	Net nominal capacity (MW)
Philippsburg 2	2019	1,402
Grohnde	2021	1,360
Gundremmingen C		1,288
Brokdorf		1,410
Isar 2	2022	1,410
Emsland		1,336
Neckarwestheim 2		1,310

Source: Federal Network Agency, 2/2018

9.4 Electricity market design

The Electricity Market Act that entered into force in 2016 develops the electricity market in the direction of an increasing share in renewable energy sources. Germany must continue to have an affordable and reliable supply of electricity even if wind and solar power increasingly dictate market activity. The Electricity Market Act plots the course for competition between flexible generation, flexible demand and storage. It also takes electricity traders to task: anyone selling electricity to customers must purchase an identical volume that suppliers feed into the grid simultaneously. This ensures that supply remains secure. Free price formation on the electricity wholesale market ensures that investment is made in the necessary capacities.

A capacity reserve should additionally safeguard the electricity supply. This reserve should be comprised of 2 GW generated by power plants, storage units or manageable loads that transmission system operators provide for emergencies. The capacity reserve is accordingly sourced separately from the electricity market and only dispatched if, despite free price formation on the electricity market, supply does not cover demand. Power plants that are part of the capacity reserve cannot participate in the electricity market and so cannot distort competition or pricing. Contracts for capacity reserves should have two-year terms. It is planned that transmission system operators enter into contracts on the basis of an open bid invitation, starting in the winter of 2019. The capacity reserve has received initial state aid approval for the period 2019 to 2025. Three invitations for bids are planned for this period. Further to this, a security standby reserve with lignite-fired power plants has also been established (see Chapter 9.2).

Securing the German bidding zone. The Amendment to the Electricity Network Access Ordinance (StromNZV) entered into force at the end of 2017. It ensures that also in coming years the German energy bidding zone cannot be divided up by the transmission system operators. Germany has a uniform energy bidding zone. This makes sure that the conditions for grid access, electricity generation and electricity consumption are the same all over Germany. In this uniform bidding zone, energy is traded without taking grid restrictions into account.

Central measures in the area of security of supply and power energy security

- Electricity Market Act
- Amendment to the Electricity Network Access Ordinance (StromNZV)
- SMARD (the new electricity market platform)
- Capacity Reserve Ordinance
- Amended Combined Heat and Power Act (December 2015 and 2016)
- Combined Heat and Power Auction Ordinance
- Act on the Redistribution of Responsibility for Nuclear Waste Management
- Commission for the storage of high-level radioactive waste (Final Repository Commission)
- Act Modernising the Repository Site Selection Act and other Legislation
- Establishment of a central market master data register
- Act amending the Gas Supply Security Regulation (EU) 2017/1938


00979
kWh
CL320 240V 3W TYPE C1SR 50TA 1.0Kh
CA 0.5
FM2S
60Hz
4235662077A47*
356 620
2/06

10 Affordable energy and a level playing field

Where do we stand?

Total spending by final customers on energy fell slightly in 2016. This was primarily attributable to the continued sharp decline in the prices for oil and natural gas on international markets.

The share of electricity costs in GDP declined in 2016 to the lowest level since 2010.

After declining the previous year, electricity prices for household customers rose by 2.4% in 2016. Prices in 2017 were approximately at the level of the previous year.

For industrial customers not covered by special compensation arrangements, electricity prices fell by 4.0% in 2016, yet went up again by 4.9% in 2017.

Growth and jobs in Germany need strong, internationally competitive businesses. Special compensation arrangements for energy prices and costs continue to make a vital contribution to maintaining Germany's position as a centre of industry.

What is new?

The Electricity Market Act that went into force in July 2016 and the amended Renewable Energy Sources Act in January 2017 will improve competition and the market for the energy transition.

Affordability Competitiveness	Maintaining affordability of energy and ensuring Germany's competitiveness.

10.1 Final consumer expenditures for energy

Final consumer expenditures for final energy consumption dropped in 2016 from €215 billion to €212 billion, as indicated by the calculations on the basis of the energy balance. In addition to an analysis of energy spending broken down by consumer group, a macroeconomic look at energy spending can provide information on affordability in general. To this end, the aggregate spending across all final consumers is considered. A comparison of the trend in expenditures compared with value added provides insight into the economic viability of energy expenditures. For example, a decline of 1.4% from 2015 to 2016 in final customer expenditures for end-use energy is contrasted with an increase in 2016 in the nominal gross domestic product. Therefore, the share of final energy spending in nominal GDP decreased on the previous year from 7.1% to 6.7%.

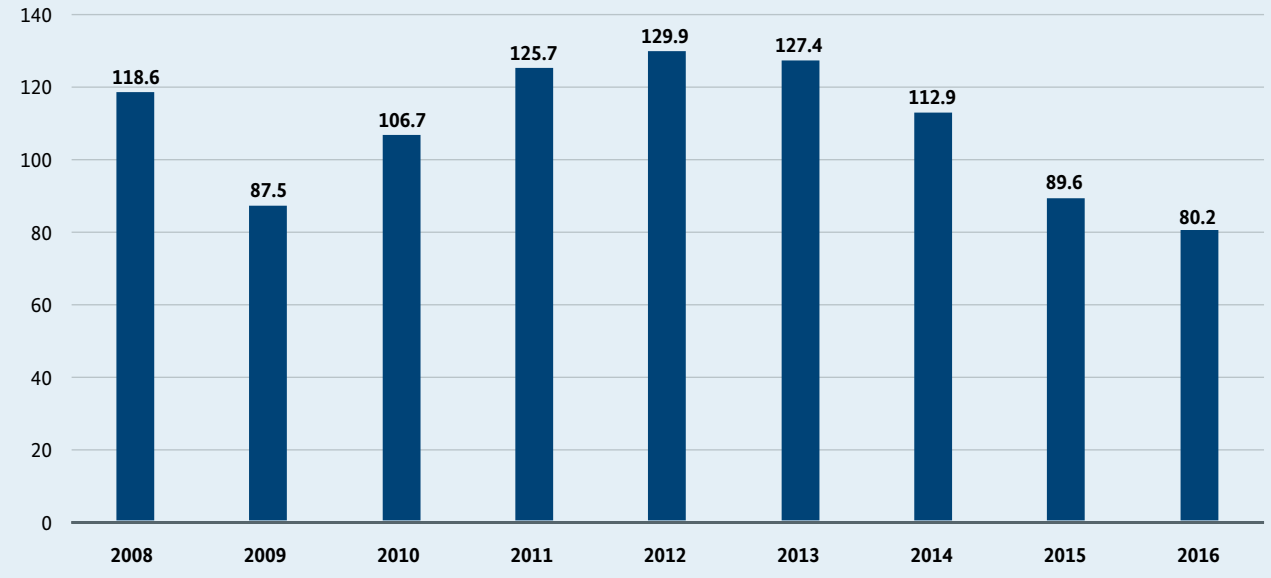
Final consumer expenditures for electricity went down in 2016, from €75.3 billion in 2015 to €74.1 billion (see Table 10.1). This reduction of 1.6% is attributable to market-driven components of electricity prices. On the other hand, expenditures related to government-induced and regulated

Macroeconomic expenditures for primary energy

Expenses incurred for provision of primary energy also have an influence on final consumer expenditures for energy. These costs dropped once more in 2016, by 10.6% to about €80 billion (Diagram 10.1). This is primarily attributable to the significant decline in import prices for fossil fuels.

Energy costs resulting from the consumption of imported fossil-based primary energy sources fell from approx. €54.8 billion to around €45.9 billion.

Diagram 10.1: Macroeconomic expenditures for provision of primary energy
billion €



Source: Federal Ministry for Economic Affairs and Energy, own calculations on the basis of the Working Group on Energy Balances and the Federal Office for Economic Affairs and Export Control, 10/2017

Table 10.1: Final consumer expenditures for electricity in € billions

	2010	2011	2012	2013	2014	2015	2016
Total expenditures (billion €)	**65.6**	**68.6**	**69.4**	**76.7**	**76.0**	**75.3**	**74.1**
Government-induced components	**21.9**	**27.9**	**28.4**	**35.6**	**37.9**	**37.1**	**38.4**
of that:							
VAT	4.7	4.9	5.1	5.6	5.7	5.8	5.7
electricity tax	6.4	7.2	7.0	7.0	6.6	6.6	6.6
concession fees	2.1	2.2	2.1	2.1	2.0	2.0	2.0
EEG surcharge	8.3	13.4	14.0	19.8	22.3	22.0	22.7
CHPA surcharge	0.4	0.2	0.3	0.4	0.5	0.6	1.3
offshore liability surcharge and charges for interruptable loads	0.0	0.0	0.0	0.7	0.8	0.0	0.2
Government-regulated components	**16.9**	**17.6**	**19.0**	**21.2**	**21.4**	**21.4**	**22.3**
of that:							
grid charges for transmission	2.2	2.2	2.6	3.0	3.1	3.5	3.8
grid charges for distribution	14.7	15.4	16.4	18.2	18.3	17.9	18.5
Market-driven components	**26.8**	**23.1**	**22.0**	**19.8**	**16.6**	**16.8**	**13.4**
of that:							
market value RES electricity	3.5	4.4	4.8	4.2	4.1	4.7	4.3
generation and supply	23.3	18.6	17.2	15.6	12.5	12.1	9.1

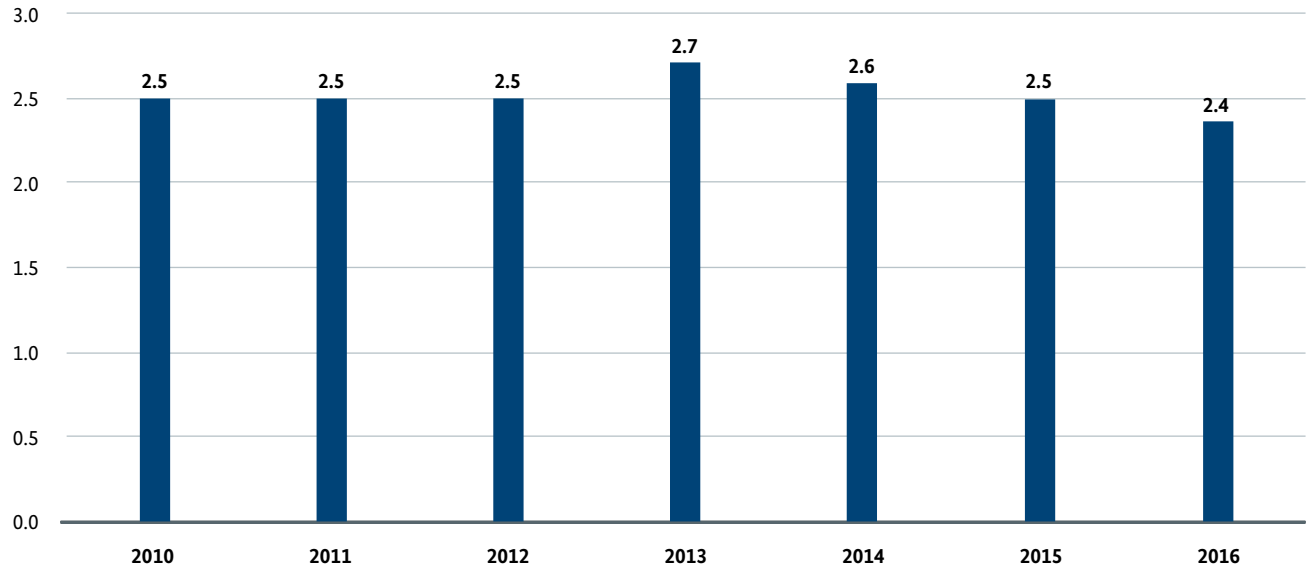
Source: Federal Ministry for Economic Affairs and Energy and estimates of the Expert Commission on the "Energy of the Future" monitoring process on the basis of the Federal Statistical Office and the transmission system operators (2017). The calculation of overall expenditures is based on proceeds from electricity sales less tax benefits from subsequent tax relief assessments. Value-added tax is only shown for private households because companies can deduct it from their tax bill.

electricity price components showed an increase. Overall final consumer expenditures for electricity recently dropped, after increasing significantly in 2013. If necessary, analyses of final consumer expenditures can be broadened and refined in the future.

Taken as a share of GDP, electricity expenditures decreased in 2016 by around 4.7%, the lowest level since 2010. In 2016, the share of nominal GDP comprising final consumer expenditures for electricity was at 2.4%, compared to 2.5% in 2015 (see Diagram 10.2).

Diagram 10.2: Share of nominal GDP comprising final consumer expenditures for electricity

in %



Source: In-house calculations based on the Federal Statistical Office and evaluations of the Expert Commission on the "Energy of the Future"

The debate on the cost of the energy transition

Statements made about the cost of the energy transition are justifiably a subject of much public attention, because their primary goal is to ensure that energy remain affordable and to maintain Germany's competitiveness. However, it is not uncommon that a cost factor is mentioned that only describes the financial cost of one specific intervention measure of energy policy, such as the Renewable Energy Sources Act (EEG) and the EEG surcharge. The transformation of the energy system is accompanied by a number of measures, however, that originally affected the electricity supply sector in particular, but increasingly addressed the transformation in the heating and transport sectors, and their interaction (sector coupling). Even if there was no formal decision on initiating an energy transition in Germany, the statutory regulations adopted between 1999 and 2002 on the Electricity Tax Act, the Renewable Energy Sources Act and the Atomic Energy Act provided an important milestone in retrospect.

Each individual measure is aimed at finding an economic means of implementation that makes it possible to reach targets cost efficiently and to ensure that the transition is affordable for all final customers. Impact studies provide assistance and can give indications regarding individual cost components of the current electricity systems or on a breakdown of energy prices into its individual components.

Adding up the individual cost elements of the current electricity system or of the cost of electricity (renewables surcharge, grid charges, etc.) cannot completely and correctly reflect the overall costs of the energy transition. In particular, this method would give the impression that energy could be provided without additional cost without the energy transition. This is, however, not the case. Such calculations would have to include the necessary investments for continuation of previous fossil-based generating installations and procurement costs for fuel imports. This exercise clearly indicates that a comprehensive cost analysis of the energy transition requires an analytical comparison between an energy system based on the energy transition, and one without. This requires a model-based macroeconomic analysis in which the energy supply of today and in the future is compared with a hypothetical world without an energy transition.

Furthermore, an energy system based on conventional energy sources inflicts climate and environmental burdens, as well as health hazards that are not fully reflected in the market prices and costs but that are borne by society. The same is true for the residual risk from nuclear energy. These added costs of the previous energy system are gradually being scaled back with the energy transition and an energy supply system that is increasingly based on renewable energy and efficiency. This is one advantage of the energy transition that must be considered in any cost evaluation in order to provide a complete picture.

The Federal Government sees cost efficiency as one of the main criteria for optimal implementation of the energy transition. The EEG surcharge cost dynamics of previous years has slowed appreciably, thanks to various amendments to the EEG (see Chapter 9). Within the scope the possibilities and challenges mentioned in the foregoing, monitoring the energy transition contributes to a broader and deeper analysis of costs.

10.2 Affordable energy for private households

Private household spending on energy dropped in 2016. On average, an individual household spent about €2,681 on energy in 2016 (see Diagram 10.3), a drop of 2.4% over the previous year. Spending on fuel dropped the most, by 5.9%. Households spent 1.6% less on average on lighting than in the previous year, yet heating costs remained about the same. By contrast, average spending on process heat, used for example for cooking, went up by around 2.4%.

The share of energy expenditure in consumer spending was on average 9.1% in 2016. For households with low net income of less than €1,300 per month, this share was at a similar level, about 9.7%. If we were to differentiate between expenses for fuels and expenses for other types of energy, there are differences. While an average of 3.4% of consumer spending of households went to fuels, the share for households with low income was only 2.0%. Other energy expenditures added up to 8.8% of consumer spending for households with low income, more than the average share, which was 5.6%. Households with low income are still finding it a challenge to afford energy costs.

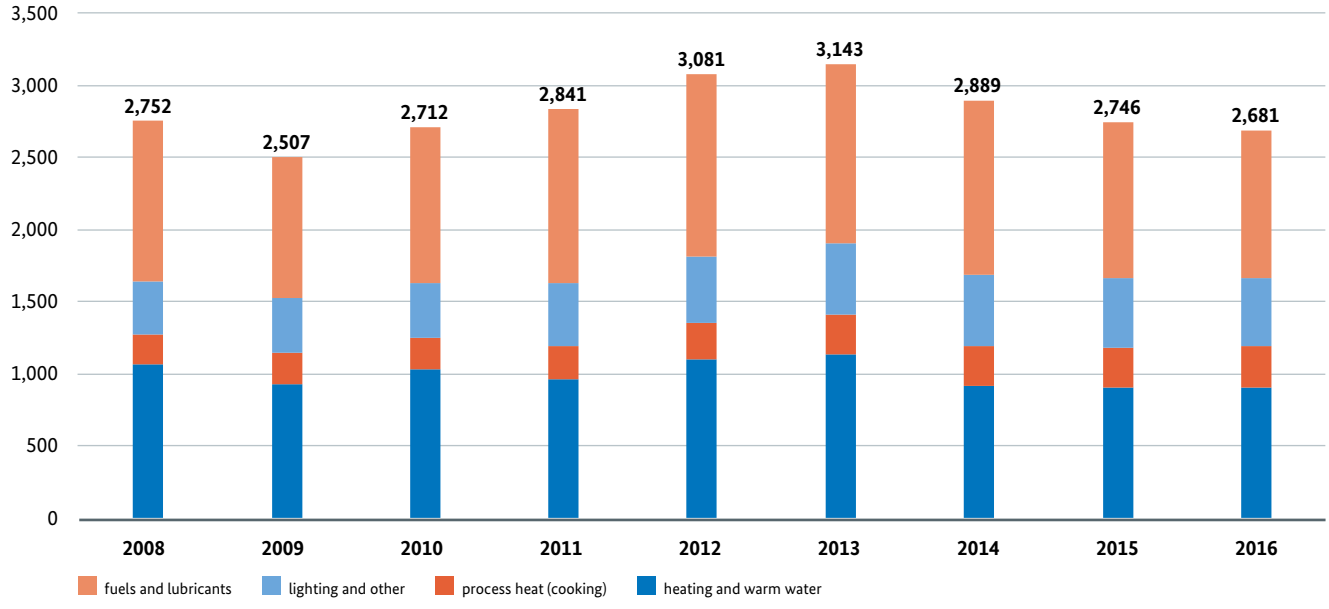
Electricity prices went up in 2016. On the reference date in April 2016, households paid 29.80 ct/kWh on average compared with 29.11 ct/kWh the year before, an increase of 2.4%. The price components for procurement and supply dropped again. However, the EEG surcharge went up on the previous year by 2.9% to 6.35 ct/kWh. Grid charges also

went up, by 3.0% to 6.79 ct/kWh (see Diagram 10.4). In 2017 the average electricity price at the reporting date was almost unchanged on the previous year, at 29.86 ct/kWh. The significantly lower procurements prices compensated for a further increase in grid charges and the EEG surcharge. The latter increased in 2017 by 8.3% to 6.88 ct/kWh. In 2018, the surcharge will drop slightly by 1.3% to 6.79 ct/kWh.

It was possible to slow cost dynamics in electricity prices in past years – this is also the result of efforts to make the energy transition as cost effective as possible. The Federal Government has rigorously continued this policy. When the Renewable Energy Sources Act came into force at the beginning of 2017, support for renewable energy and CHP was shifted to competitive calls for bids. This quickly led to very significant cost reductions in further development of renewables, as the results of previous tenders for photovoltaics and wind energy clearly indicate (see Chapter 4.5). A medium-term attenuation of cost trends was also the aim of the Network Charges Modernisation Act that entered into force in July 2017 that defines a removal of costs incurred from avoided grid charges. Due to the strong competition in the market for end user electricity suppliers, customer can also save money by changing their supplier.

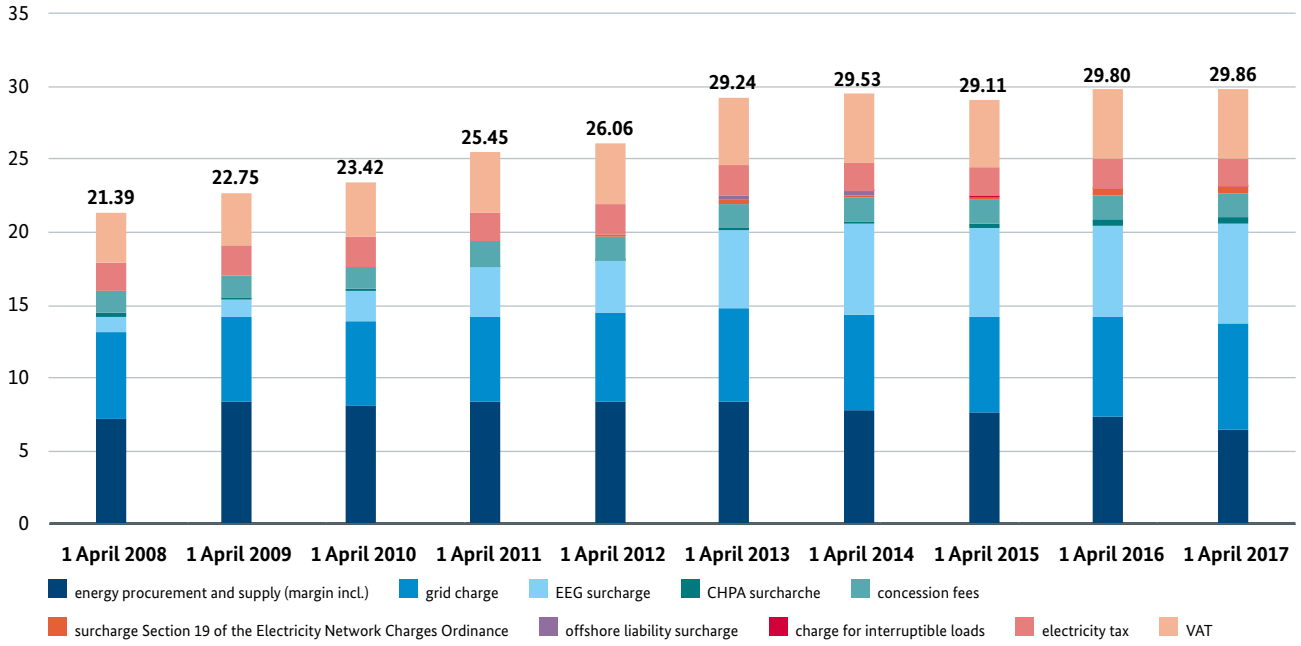
The development in consumer prices for oil and natural gas is primarily attributable to the sharp drop in commodity prices on the international commodity markets in recent years, also in 2016. Import prices for natural gas were down 24%, and for crude oil, by 20%.

Diagram 10.3: Average annual energy spending of private households
in Euro



Source: BMWi based on the Federal Statistical Office and the Working Group on Energy Balances 11/2017

Diagram 10.4: Average annual energy spending of private households
in ct/kWh



Source: Federal Network Agency, 11/2017. The data were captured on the reference date of April 1 of each year. A household with an annual consumption of 3,500 kWh was taken as the basis up to 2015. Since 2016, data have been based on an annual consumption of between 2,500 and 5,000 kWh.

Central measures in the area of affordable energy for private households and industry

Legislation

The **Renewable Energy Sources Act 2017** that entered into force at the beginning of 2017 strengthens the principle of the economic, cost-effective and environmentally compatible implementation of the energy transition by marking the transition to competitive auction systems, inter alia (see Chapter 4).

The **Network Charges Modernisation Act** entered into force in July 2017, and also helps to regulate the gradual removal of the costs incurred from avoided grid fees. Between 2017 and 2018, the costs for avoided grid charges in electricity distribution systems sank overall by more than €1 billion, which resulted in a corresponding cost savings for energy consumers. Both measures can help to significantly reduce costs to the final consumer that arise from operating, modernising and expanding the electricity grid (see Chapter 12).

With the **Ordinance on the Transparent Itemisation of State-imposed or Regulated Price Components in the Basic Supply of Electricity and Gas**, the Federal Government increased transparency for consumers, thereby making it easier to compare rates. Changing provider can help consumers reduce spending on energy.

Other measures

The efficient use of energy and energy conservation will be the foundation for less energy spending in future. To this end, the Federal Government launched the following measures in particular:

- **National Action Plan on Energy Efficiency** (NAPE)
- **Germany Makes it Efficient awareness raising campaign** (see Chapter 5)
- **Efficiency Strategy for Buildings** (ESG)

Despite the progress made in the energy transition, Germany will continue to depend on imports of fossil fuels, at least on the medium term. For this reason, the cost of energy also depends greatly on the import prices. Germany's **international energy policy** will continue to aim at the greatest possible diversification of energy suppliers and transport routes, also with a view to ensuring the stable development of import prices (see Chapter 3).

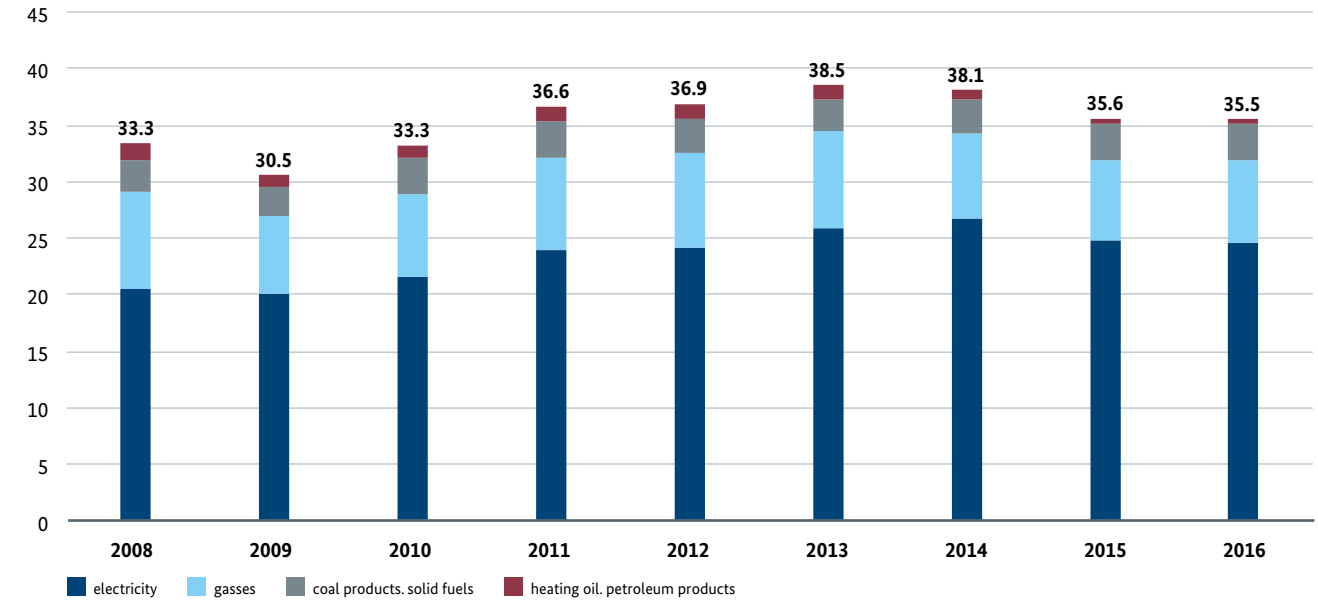
10.3 Affordable energy for industry

German industry spent approximately the same amount on energy in 2016 as in the previous year. Energy is an important cost factor for industry and therefore has a bearing on the ability of industry to compete with other countries. Industry spent a total of €36 billion on energy in 2016 (Diagram 10.5), as in the previous year. Price declines made up for the 1.3% increase in consumption. Prices on the global energy commodity markets dropped strongly once again. The prices for petroleum products, such as heavy fuel oil, dropped significantly in 2016 compared with the previous year, by 17%. The price of gas also fell by 17% from 2.95 ct/kWh to 2.44 ct/kWh. Spending on electricity decreased slightly in 2016, going from €25.1 billion to €24.9 billion. Lower electricity prices are the reason that expenditures dropped, despite a 0.7% increase in power consumption (see below).

Electricity costs account for around two-thirds of total energy costs for industry. Electricity costs are therefore particularly relevant for energy costs. However, the share of electricity in final energy consumption differs significantly in the individual sectors. In addition, the prices can vary widely from business to business. For example, individual offtake amounts and profiles have a bearing on the pricing. Regional differences also exist, such as in the case of grid charges, for instance. Various special compensation arrangements mean that highly electro-intensive businesses that face strong international competition pay lower levies and surcharges under certain conditions. This price relief is not financed by privileged final consumer.

Electricity prices for industrial customers not covered by special compensation arrangements fell slightly in 2016, but went up again in 2017. According to the findings of the Federal Network Agency, electricity prices for industrial customers (annual offtake 24 GWh) that do not fall within the scope of statutory special compensation arrangements were essentially in the range from 12.91 to 15.69 ct/kWh (excluding VAT) on the reference date 1 April 2016. Average prices on the reference date in 2016 had dropped by 4.0% compared with the previous year, falling from 14.80 to 14.21 ct/kWh (see Diagram 10.7). This was primarily due to a decrease in the price component for procurement, supply and margin. This decrease is probably due mainly to the wholesale prices that fell again significantly at the beginning of 2016 (see diagram), which was prior to the date the Federal Network Agency raised prices. Also contributing to the drop in electricity prices was the decrease in grid charges for industrial customers, who are not covered by special compensation arrangements, by 0.06 ct/kWh to 2.06 ct/kWh. In this context it is important to note that some industrial customers with high annual consumption levels and steady offtake agree separate grid use contracts with their system operator, and thereby pay customised grid charges. In 2017, electricity prices went up on the reference date, 1 April, by 4.9% to 14.90 ct/kWh.

Diagram 10.5: Energy costs of industry
million €



Source: BMWi based on the Federal Statistical Office and the Working Group on Energy Balances 10/2017

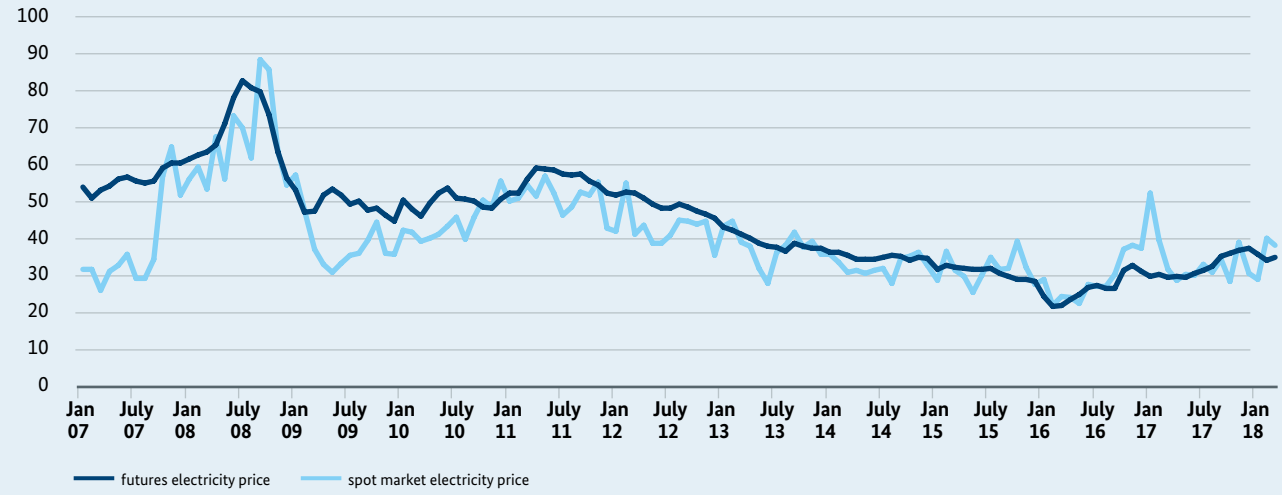
Prices of electricity on the exchange

The long standing downward trend in prices in power exchange trading turned around in the second half of 2016. On the European Energy Exchange (EEX), the price for delivery in the following year (baseload, year future) for the annual average in 2016 fell by 14% compared with 2015, to about €27/MWh. However, this was basically attributed to the downward trends in prices at the beginning of the year. In the second half of 2016, the exchange price followed an upward trend, and in December 2016, was at about €31/MWh, as high as mid-2015 (see Diagram 10.6). In 2017 this upward trend continued measured over the year as a whole. In December, the exchange price was €38/MWh. The spot market prices were surprisingly high in early 2017. This was attributable to cool weather and high electricity demand in France. Seen over a long reference period, however, the exchange price in 2017 was still at a comparatively low level. On the spot market, prices indicated a comparable trend to that of the futures market, with expected high volatility. The price level was usually similar. Prices on the futures market indicate that the exchange participants on the exchange expect wholesale electricity prices to tend to rise in the near future.

If a large supply of cheap energy meets low demand, negative exchange prices could be the result. This can happen for example if low demand either early in the morning, on public holidays or on the weekend is met with high feed-in from wind and photovoltaics due to weather conditions. Negative prices can provide an investment impetus for making conventional power generation more flexible and, increasingly, also demand. In 2016 there was a total of 97 hours with negative prices on the spot market – a share of 1.1%. In 2017 there was a total of 146, a share of about 1.7%. On-exchange trading is the major portion of energy trade. Another part of electricity is traded through over-the-counter bilateral contracts which, however, are also influenced by pricing signals from the electricity exchange. Such contracts often have multi-year terms.

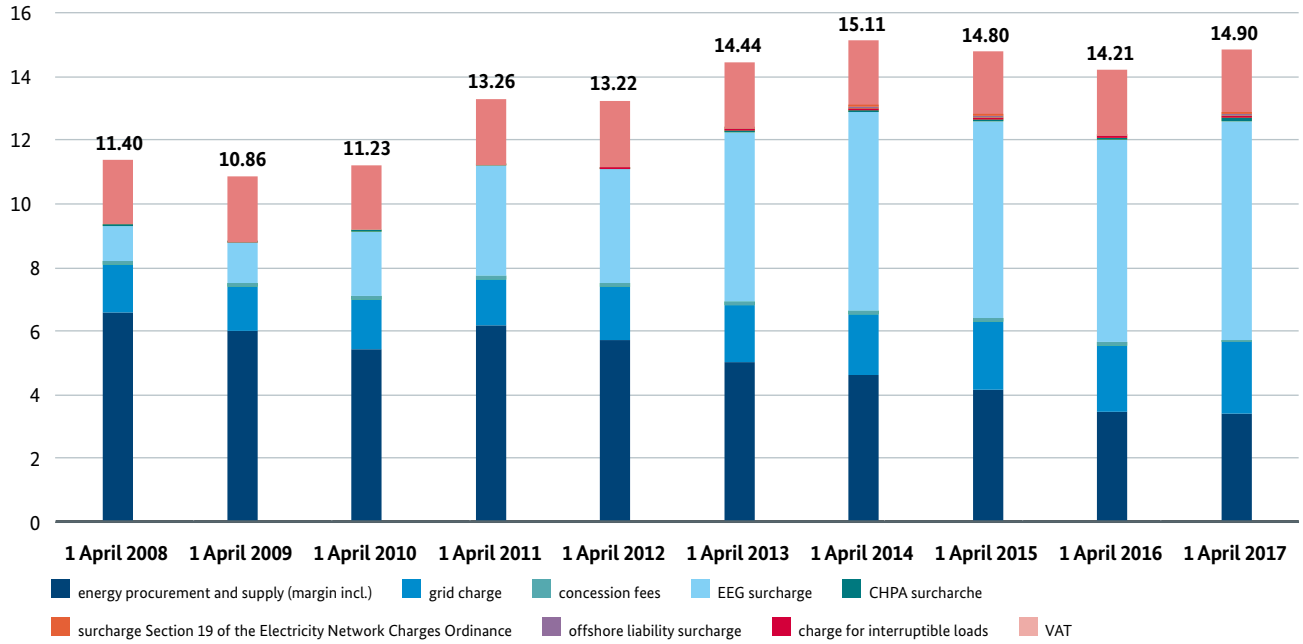
Diagram 10.6: Electricity prices on the exchange in the spot market and in futures trading

in Euro/MWh



Source: European Energy Exchange, 03/2018
Monthly average values for the products "Day Base" (hour contracts) and "Phelix Futures" (baseload, year future)

Diagram 10.7: Electricity prices for industrial companies not covered by special compensation arrangements
in ct/kWh



Source: Federal Network Agency, 11/2017. The data were captured on the reference date of April 1 of each year. Annual consumption of 24 GWh (annual peak load 4,000 kW and annual duration of use 6,000 hours) at medium-voltage level is assumed. Tax amounts before 2013 include VAT.

10.4 Affordable energy for a competitive economy

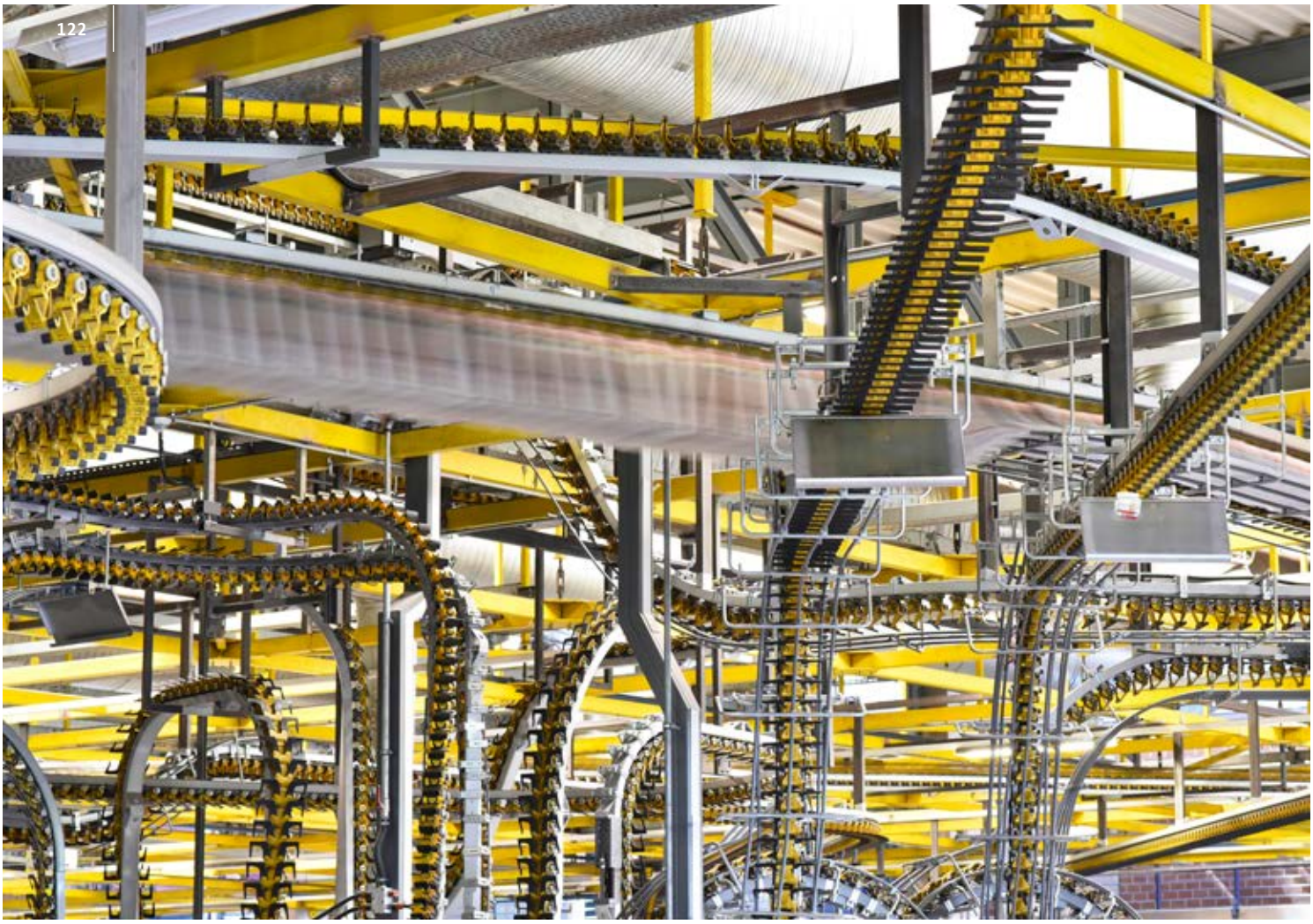
Growth and jobs in Germany require strong, internationally competitive industries. The energy-intensive industries, in particular, are the basis for maintaining closed value chains and for downstream production sites to set up in Germany. The therefore make a considerable contribution, both directly and indirectly, to creating and keeping skilled jobs in Germany. However, the competitiveness of German companies, and particularly of industry, depends not least on local energy prices compared with other countries.

Fuel and natural gas prices in Germany were at a level similar to the EU average in 2016. The prices of diesel fuels, for example, were 1.0% below the EU average, while gas prices for industrial customers in Germany were almost 8.5% above the European average.

Even though electricity prices did drop for many German industrial and commercial companies in 2016, electricity prices still remained above the EU average. According to figures released by Eurostat for the second half of 2016, the prices for small commercial and industrial customers with an annual consumption of less than 20 MWh were 17.5% above the EU average, while medium-sized industrial customers with an annual consumption of 70-150 GWh had to contend with prices 15.1% above the EU average (figures are exclusive of VAT and recoverable taxes and levies).

With regard to electricity prices for highly electro-intensive businesses, Germany is around average compared with other EU countries owing to various special compensation arrangements – this was the finding of a study conducted by Ecofys, ISI (2015) on the basis of data for 2014. The international comparison of electricity prices is particularly relevant for businesses whose production process are energy-intensive and which are highly exposed to international competition. Various special compensation arrangements are in place to ensure that the cost of the energy transition does not put such companies at a competitive disadvantage. The electricity price for these companies is primarily determined by the costs for procurement and supply, with the result that, inter alia, the low prices on the electricity exchange have a positive effect.

Special compensation arrangements are essential to maintaining Germany's position as a centre of industry and are in the interests of the economy as a whole. For the Federal Government it is clear that the competitiveness of German industry must not be put at risk. The objective is still to avoid production moving offshore to countries with lower environmental standards and/or lower levies on energy ("carbon leakage") and to secure closed value chains and industrial jobs in Germany in the long term. The special compensation arrangements under the Renewable Energy Sources Act and the Combined Heat and Power Act mean higher electricity prices for private households and non-privileged businesses. On the basis of the current annual



accounts, the relief provided through the mechanism of special compensation arrangements was financed in 2016 by 1.46 ct/kWh, or 23%, of the EEG surcharge.

Regulations preventing carbon leakage help reconcile the competitiveness of German industry with climate change mitigation requirements. It is already a fact today that the German economy produces more but has less greenhouse gas emissions (see Chapter 8.3). For businesses whose products face strong international competition, the aim is to limit the cost burden of CO_2 reduction so that carbon leakage is avoided, thereby ensuring the local economy remains strong. At the same time, appropriate regulations are needed for global climate change mitigation also, to limit greenhouse gas emissions and not shift them to countries which also have lower climate change mitigation standards.

Unit Energy Costs (UEC)

Apart from the price of energy, a business enterprise's energy costs are also dictated by the amount of energy it consumes. Energy consumption not only depends on how much is produced but also on how efficiently energy is used. Therefore, higher energy prices compared with another location can be offset to some extent by the more efficient use of energy and thereby by reduced energy intensity in production in individual sectors. Both factors – energy prices and energy efficiency – can be considered together in the Unit Energy Costs (UEC) indicator. To determine UECs, aggregate energy costs are basically divided by gross value added or gross production (gross value added plus intermediate inputs). However, various approaches to a more exact calculation are being discussed by academics. In general, its validity as an indicator of the cost burden of businesses and of competitiveness is not without controversy.

Calculations based on official statistics find, for example, that the average UEC for German industry in 2015 stood at €17.15 per €1,000 gross production value. The value for 2014 was €18.48.

Central measures towards establishing a level playing field

- EEG Special equilisation scheme and special compensation arrangements for self-supply
- reductions in the CHP surcharge
- relief provided by the Energy Tax Act and Electricity Tax Act, e.g. energy tax cap
- free allocation, in some cases, in the EU emissions trading system (see Chapter 3)
- relief from grid charges

11 Environmental compatibility of the energy supply system

Where do we stand?

The energy transition gives rise not only to beneficial effects for the environment and synergies for sustainable energy sector, but also possible new consequences for the environmental and health as well as impacts on nature and the landscape.

A suitable indicator is currently being developed to correctly and scientifically reflect changes in the environment attributable to the energy transition. The goal is to use constant, scientifically-based monitoring processes to identify early on and avoid any damage to the environment, as much as possible.

What is new?

Extensive research is currently underway on assessing the ecological impacts of expanding renewables and modernising infrastructure, as well as developing preventive measures. The results of these studies will be used to systematically develop an environmental monitoring process for the transition. The results of this monitoring will take the results of this chapter into account, thus boosting public acceptance.

The first Nitrogen Report of the Federal Government of May 2017 emphasizes the necessity of reducing nitrogen pollution with a cross-sector approach to a minimum amount that is compatible with the environment and human health.

Environmental compatibility	Creating an energy supply system that is environmentally compatible and protects natural habitat.

Starting with the triad of energy-policy goals as a central point of orientation (see Chapter 2), this Monitoring Report has a separate chapter on environmental impacts of the energy transition. Any type of energy conversion usually has impacts on the natural environment, humans and resources. For this reason it is important to provide necessary protection of natural sources of life, also as a responsibility to future generations. The goal of the new environmental audits of the energy transition is to make clear what the effects of the energy transition have already been in past years in order to improve environmental performance and to indicate what further impacts can be expected. Ecological compatibility is a central aspect of the future face of the energy transition.

In this sense, it is essential not only to prove that greenhouse gases are going down, but also to ensure that any environmental impacts or effects on human health or nature and the landscape attributable to the energy transition are identified early on. If, for, example, less fossil fuels are burned and Germany phases out nuclear energy, environmental pollution will be greatly reduced, thereby lowering health risks. On the other hand, it is important to ensure that the continued expansion of renewable (see Chapter 4) energy and other technological developments (see Chapter 14) do not result in greater negative – or especially serious – impacts on health and the environment.

The first step for monitoring the effects of the energy transition on the environment and human health is to establish a quality evaluation tool for the effects and changes in the environment accompanying the energy transition. Comparable times series – like those for the development of greenhouse gases – are not yet available for assessing the environmental compatibility of the energy system (see Chapter 8). For this reason, the Federal Environment Agency commissioned a study in order to close this data gap. Other research projects are currently being developed for the Federal Agency for Nature Conservation. The pressing issue is to determine the impact of expanding renewables and the energy grid on nature and the landscape. Another focus of research is also developing means for avoiding conflicts between nature conservancy and renewables expansion. The Federal Office for Radiation Protection is running a research programme on radiation protection in conjunction with expansion of renewable energy.

The results of this study will be used to systematically develop a new environmental monitoring process for the energy transition. As will be described in more detail in the subchapters that follow, the focus should be on effects of the energy transition – the energy system and its transformation – in the areas of

- soil, air and water (Chapter 11.1)
- natural resources and land use (Chapter 11.2)
- nature and the landscape (Chapter 11.3)
- human health (11.4).

This is an ongoing process. The following provides an initial overview of these separate aspects of future environmental monitoring of the energy transition.

11.1 Soil, air and water

The energy industry is responsible for a large portion of air pollution in Germany. In addition to greenhouse gases, air pollutants in particular are released in all sectors in which fossil fuels and biogenics are burned. As an example, in 2015 the energy sector was responsible for a major portion of nitrogen oxide emissions (about 25%), sulphur dioxide emissions (over 60%), particulate matter (PM2,5, almost 9%) and mercury emissions (about 65%). These pollutants are not only harmful to the environment but also have an adverse effect on human health.

In the energy sector, coal-fired power plants in particular emit substantial amounts of pollutants into the air. They contribute the largest portion of sulphur dioxide emissions produced by the energy sector, at 54%. Mercury emissions are at around 65%, nitrogen oxide emissions at 17% and particulate matter at 10% of total energy sector emissions. However, it should be noted that the energy-related emissions of "classic" air pollutants such as nitrogen oxides, sulphur dioxide, volatile organic compounds, ammonia and dust or particulate matter have gone down sharply since 1990. The investment cost of any additional measures should be weighed against the environmental benefits.

In 2016, replacing fossil fuels with renewables – taking the upstream chains into account – avoided net greenhouse emissions of about 160 million tonnes of CO_2 equivalent. The electricity supply sector accounted for emissions of 119 million tonnes of CO_2 equivalent. The use of renewable energy sources in the heating sector reduced emissions by 35 million tonnes of CO_2 equivalent, and the use of biogenic fuels, by 6 million tonnes. For 2017 measurements indicate that renewable energy resources will lead to a reduction of around 179 million tonnes of CO_2 equivalent (See Chapter 8.2).

The use of renewable energy resources may however also cause additional air pollutants. Combustion of biomass in relatively small and decentralized plants can give rise to nitric oxide and dust. Distributing biological fermentation residues from biogas plants can lead to additional ammonia emissions that cause acidification of the soil and over-

fertilisation, as well as creating additional secondary particulate matter. For this reason, it is important to evaluate new and previous energy conversion systems in their broader context. Chapter 11.4 contains information on the share of overall nitrogen emissions created by the energy sector and industry.

Data on regional emissions from energy production affecting the soil and water are also available. These figures are however more useful in determining local or regional pollution (see the national Pollutant Release and Transfer Register – PRTR). In addition, acreage for energy crops, in particular maize, has increased significantly in recent years in some regions. However, changes in the Renewable Energy Sources Act have helped slow down the increase in maize acreage for bioelectricity production. In particular, as agriculture use has intensified, nitrate levels in the groundwater and in surface waters has gone up, as well as increased discharges of ammonia, nitric oxide and nitrous oxide. In general, all pollutants emitted into the ambient air can also make their way into soil and water. These possible indirect effects should also be taken into account.

In addition to material contamination, the non-solid impact of the energy sector, for example, on bodies of water, must be taken into account. For one, this includes direct trading intrusions, especially when hydropower is used to create energy. For another, the intake of cooling water by power plant also disturb the ecosystem of rivers, its material and thermal structure. This situation has improved in Germany in the past years. The volume of cooling water used went down between by about 7 billion cubic metres between 2010 and 2013. In 2013, cooling water accounted for 54.2% of total water use (25.1 billion cubic metres). This ratio is expected to become even smaller through the expansion of renewable energy. The energy industry affects not only surface waters but also groundwater – for example with open-pit mining or geothermal plants – with its material pollution, but also by affecting the water level.

It is important to measure the effects of renewables on transport, not only by using biofuels, but also as a result of electric mobility. The switch to electric and other alternative drivetrains lowers to a certain degree pollutants and climate gas emissions incurred by combustion, and in some instances shifts them to the electricity supply sector (see Chapters 7.2 and 13.1). This shift will also be aggravated by using power-to-x products such as green hydrogen, which has practically no emissions, at about 13g CO_2/MJ H_2, if exclusively electricity from renewable energy is used to create the hydrogen.

11.2 Natural resources and land use

The demand for natural resources and where energy plants are located are factors for any type of energy generation – due both to climate change mitigation and environmental considerations and to economic efficiency. With highly efficient use of resources and sustainable land use, the energy transition can be a model for climate change mitigation. Efficient use of resources requires resource-efficient planning, production and operation of plants as well as mostly closed resource loops. If natural resources must be imported, it is also essential to comply with international environmental and social standards during raw material extraction and to increase transparency of resource supply chains.

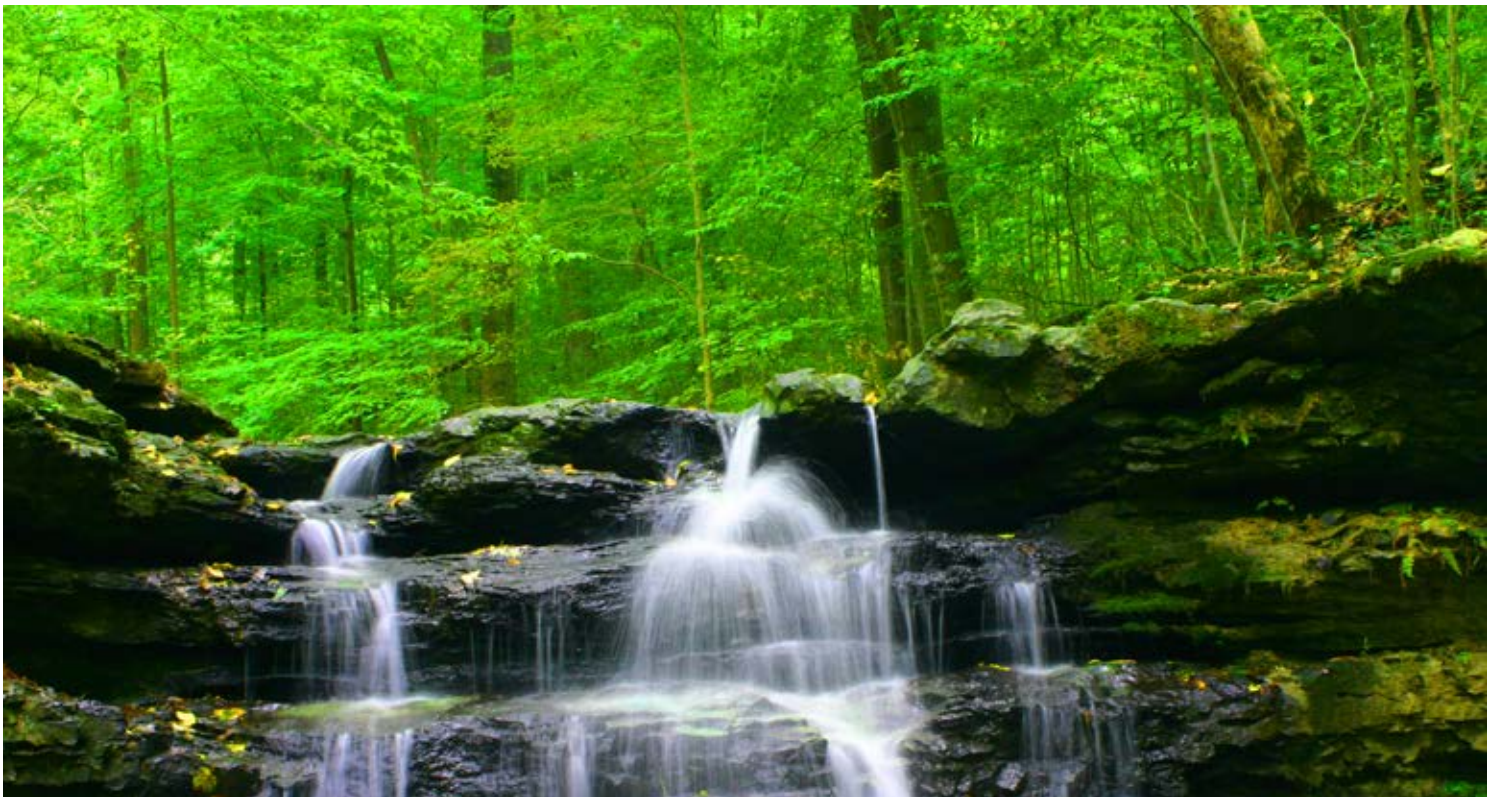
Many natural resources used in the fossil-nuclear sector cannot be recycled, or only inefficiently. On the other hand, there is a growing number of efficient recycling concepts for materials used in utilising renewable energy. Accompanying technologies are continually being developed and made more efficient. In the future it will be essential to put emphasis on recyclability during the R&D phase, especially for composite materials and lightweight construction components. A greater emphasis on using power from renewable energy sources at the stage of raw material extraction as well as in manufacturing plant components will reduce even further the climate and environmental impact of energy produced with renewables.

In order to minimise acreage used for extraction, processing and transporting energy sources and energy facilities, including upstream value chains, and to avoid the loss of agricultural land, part of the environmental monitoring should take into account the acreage required for conventional power plants and for extracting fossil fuels such as lignite. On the other hand, it is important to remember that renewable energy requires space and changes the use of those spaces. Notably, this includes ground-mounted photovoltaics, wind-powered installations and agricultural and forestry-based production of biomass. In conventional generation, future changes in land use should be considered, for example in the case of lignite excavation sites that are replanted.

The conversion of the energy systems also has an influence on utilization of land and type of utilization. Although it is projected that there will not be an increase in acreage used for extraction of fossil fuels, the space required for renewables and its various effects on such space in comparison with conventional energy generation will be greater on the whole. With the conversion to renewables, the structure of energy conversion and use can also be shifted to a small number of central sites to a multitude of smaller, decentralized sites.

The individual renewable technologies also require widely differing amounts of space and have differing effects on nature and the landscape. According to the Specialized Agency for Renewable Raw Materials, in 2016 an area of about 1.48 million hectares (almost 8% of agricultural acreage) was used for cultivating plants for energy. About 960,000 hectares were used for cultivation of renewable resources for bioenergy generation (mostly rapeseed). In addition, in some areas cultivation of biomass for energy crops leads to a loss of grassland. which is disadvantageous to maintaining biodiversity and numerous ecosystem activities.

Using bioenergy produced from residue and waste material is an important step toward avoid competing with food producers for utilization and space and conflicts with nature conservation, as well as rolling back the share of bioenergy to make room for more space-efficient energy sources such as wind energy or photovoltaics. Developing efficient strategies for using biogenic resources is important in this process.



Efficient production and distribution of renewables and lower energy consumption could help slow down land take and contribute to a decrease in competition for space and the stress caused by agriculture. Technologies that are also helpful in reducing land take are basically those that are close to consumers or are used on space that has already been sealed, such as generation of solar energy on roofs and house exteriors as well as heat pumps or geothermal energy.

11.3 Nature and the landscape

Whenever efforts are made to protect biodiversity and basic resources for nature and humans, the energy transformation becomes much more acceptable. In general, it is apparent that structural change in the energy sector brings about completely new effects on the environment – influencing the appearance of the landscape, the ecosystem and biodiversity. At the same time, reduced use of conventional fuels lowers the burden on nature.

The effects on nature and the landscape from construction and operation of various conventional and renewable energy plants as well as the network Infrastructure are very diverse. This includes use of space, loss of living space, impairment of soil and water as well as the damage done to the image of the landscape. Furthermore, there are impacts on animals, plants and biodiversity. A possible conflict through disruption or loss will be regularly reflected in planning and approval in the scope of endangered species and territorial protection. In doing so, there are binding EU regulations that must be adhered to.

Onshore wind energy: Optimising the selection of sites to the most acceptable areas when planning, evaluating and grating approvals will serve to avoid any possible negative effects on animal species and their living space as well as the landscape – not to mention the interests of the residents. Spatial planning of the *Länder*, (*Länder* and regional planning) as well as municipal development planning in particular contribute to this. The major portion of wind-powered installations are located on agricultural land. Some *Länder* are starting to erect wind power plants in forests. In 2016, about one-fourth of power installations in forests started operation. Depending on *Länder* regulations, some wind power plants are allowed in certain protected areas. Regarding the appearance of the landscape there is currently a consensus of most *Länder* that damage cannot be reversed and therefore they have determined direct compensation under the Federal Nature Conservation Act. In addition to the selection of sites there are other ways to minimise conflict. This includes for example newly developed technologies and avoidance measures. To avoid the risk of collision, for example, to protect bats there are multiple requirements for turning off wind plants and to protect certain species of birds, there are regulations on distance between towers. The demand for agricultural and forestry biomass for generating energy can on the one hand impair biodiversity through loss of living space and ecological natural habitat functions, and on the other, possible synergies can arise between the expansion of renewable energies and protection of biodiversity, for example by using landscape management materials for energy generation.

Offshore wind powered installations: The construction and operation of these installations may have impacts such as noise disturbance for marine mammals. They can impair habitats of birds and bats, as well as protected biotopes. The Federal Ministry for the Environment in 2013 developed a noise abatement program for the Exclusive Economic Zone in the North Sea that would require construction on offshore wind powered installations to be executed such that harbour porpoises would be provided with sufficient room to retreat.

The use of wood for energy purposes has increased in recent years, especially for heating installations as well as heating plants and CHP plants (see Chapter 4). Currently, around half of the forest wood used in Germany is utilized directly for producing energy. The potential for wood is quite limited; any increase in demand could come at the cost of biodiversity in the forest. Using wood can under specific circumstances have ecological climate change mitigation advantages, but also avoid competition between material exploitation and use for energy production. Even reducing the final energy consumption in buildings (see Chapter 6) can provide a substantial contribution toward protecting the forests.

Hydroelectric power station: To limit the impact of construction and operation of such installations on nature and the landscape, well-known precautions are taken to protect animals, plants alluvial areas (e.g. fish ladders). Germany has only limited additional potential for hydropower plants anyway.

The Nature Conservation and the Energy Transition centre of expertise (KNE) that began its work in July 2016 provides impetus toward avoiding conflict during the increase in use of renewable energy. The KNE centre of expertise helps to bring greater professionalism into the debate and assists in avoiding conflict on the ground.

11.4 Impacts on human health

The energy sector emissions described in Chapter 11.2 also affect human health. For example, nitrogen oxide (NO_2) is a byproduct of combustion plants and combustion engines that is harmful to respiratory passages and makes other pollutants even more irritating, which may lead to respiratory or cardiovascular disease. Particulate matter is also harmful to human health. For one, hazardous substances can collect on the surface of dust, and for another thing, dust particles themselves pose a health hazard. In contrast to other pollutants, the WHO has determined that there is no particulate matter concentration for which there is a lower threshold under which no damage can be expected. Regarding particulate matter that is not of a natural source, these could also stem from combustion processes, such as wood furnaces, vehicles and some industry processes. A large portion of particulate matter forms in in the atmosphere from gaseous substances such as sulphur oxides and nitric oxides, ammonia or hydrocarbons.

Not only emissions, but also noise pollution can have negative effects on human and animal health. Being exposed to consistently high decibel ranges can lead to health issues. In order to properly assess the effects of the energy system, it is important to take noise pollution into consideration. This includes noise emissions from onshore wind energy generation. On the one hand, wind energy offers the greatest potential for growth of all sources of renewable energy, yet on the other hand, because Germany is so heavily populated it is important to locate sites that are sufficiently removed from residential areas. Nevertheless, the technology involved in wind-powered installations has greatly improved in recent years. As a result, wind plants have not only become more efficient, but have also been improved to lessen their impact on the environment and human health. Current research indicates that the noise impact of infrasound is very minor compared with other sources, and has no negative effects on human health. Other decentralized heating systems (e.g. heat pumps, CHPS) can meanwhile cause significant noise disruption due to low-frequency noise and infrasound, especially if they were not installed properly.

Traffic, a major component of the energy system, is one of the major producers of noise. Every five years the impact of ambient noise in metropolitan areas is mapped, along the main traffic arteries and at large airports. The noise map from 2012 shows that over 4.8 million residents are exposed to nightly noise levels of over 55 dBA and almost 3.5 million residents are exposed all day long to sound levels exceeding 65 dBA. Further growth of electric mobility (see Chapter 7.2) can help reduce this noise exposure and thereby improve the noise situation.

Electricity-conducting components may cause electromagnetic fields. High electric field strength may be a risk to human health. Installation and operation of power lines in transmission and medium voltage grids are therefore subject to the provisions of the 26th Regulation on Implementation of the Federal Immission Control Act. This Regulation defines immission limits and a requirement to reduce immissions. Charging points and power trains in e-vehicle (see Chapter 7.2) are subject to the requirements set forth in the Product Safety Act. The Immission Control Act is also applicable to inductive charging stations operating above a specific frequency band.

In addition to environmental and health impacts of installations during normal operation, the possibility of disturbance due to disruption of operation or damage should also be taken into consideration. Severe cases are very seldom, but could have far-reaching consequences. The phase out of nuclear power for production of electricity should reduce the risks posed by release of radioactive substances. The safe permanent disposal of radioactive waste will help minimise over long periods of time the radioactive aftereffects of the use of nuclear energy. Native impacts of renewable energy resources can be assessed as being minor in general, due to their decentralised nature and in comparison to large, centrally-located installations with high energy output. As a result, it is expected that the energy transition will reduce the risk of damage overall.

Central measures in the area of ecological compatibility

German Resource Efficiency Programme II

- Holistic view of material efficiency and energy efficiency, strengthen environmental, social and transparency standards in the natural resources sector and create a more sustainable supply chain
- Consider resource conservation in the product development phase
- Develop and disseminate resource-efficient manufacturing and processing information
- See Chapter 16 for a report on the status of the implementation of individual aspects

The first Nitrogen Report of the Federal Government

- The first Nitrogen Report of the Federal Government published in May 2017 emphasizes the necessity of a cross-sector approach to reducing nitrogen pollution to an amount that is compatible with the environment and human health. The formulation of the energy transition affects the amount of nitrogen emissions (e.g. spreading fermentation residues), including ammonia, nitrous oxide and nitrate emissions (agriculture) and nitric oxide emissions (energy generation and transport).
- In Germany, agriculture contribute 63% to annual overall nitrogen emissions, in the amount of 1.5 million tonnes of nitrogen. The energy sector and industry contribute 15% each, transport 13%, and the remaining 9% come from waste water and surface runoff (Federal Government 2017).

Environmental monitoring of the growth of renewable energy in the area of electricity

- Research commissioned by the Federal Agency for Nature Conservation aims to instigate environmental monitoring of the growth of renewable energy in the area of electricity.
- In addition, instruments for avoiding disruption to nature and the landscape will be developed.

BGZ Gesellschaft für Zwischenlagerung mbH, a federally-owned company for interim storage of nuclear waste

- The Act on the Redistribution of Responsibility for Nuclear Waste Management that entered into force June 2017 created new rules on who is responsible for shut-down and dismantling of nuclear power plants and who deals with and pays for nuclear waste management.

Prohibition on unconventional fracking for extracting natural gas and oil

- In February 2017 statutory rules on fracking entered into force that provide for extensive prohibitions and restrictions on the use of fracking technology in Germany. Fracking is generally prohibited. The Länder may approve of a total of four research measures nationally to provide answers to unresolved issues.

12 Grid infrastructure

Where do we stand?

The grid expansion measures that have been agreed must be implemented without delay. Around 40% of the Power Grid Expansion Act projects had been implemented by the end of the first quarter of 2018. More than half of the projects have already been approved, however. The Thüringer Strombrücke (Thuringia electricity network) went online completely in September 2017.

Just as important is implementing the projects under the Federal Requirements Planning Act as quickly as possible. This process has entered the next phase, as federal planning has commenced for the big extra-high voltage, direct current transmission lines SuedLink and SuedOstLink in 2017, and for A-Nord in early 2018. Of the almost 6,000 km total length of the lines under the Federal Requirements Plan Act, about 150 km had been completed in the first quarter of 2018. Operation of these lines that are essential for transporting electricity from north to south is planned to start in 2025 given optimal conditions.

In terms of grid stability and quality, the reliability of the grid infrastructure in Germany remains at a very high level.

Grid charges for household customers dropped by 3% in 2016. However, for certain industrial customers they went down by 2.8%.

What is new?

The Renewable Energy Sources Act 2017 embodied the first steps toward better alignment of the growth in renewable energy and the expansion of the grid.

In order to reduce costs of network congestion problems in the transmission grid, in early 2017 the Federal Ministry for Economic Affairs and Energy launched a comprehensive stakeholder process and together with the participants, worked out an action plan that, in addition to grid expansion, should lower the macroeconomic cost and in the short term, increase capacity utilization of the power grid.

Costs of grid expansion and operations are distributed more fairly: The Network Charges Modernisation Act (NEMoG) that entered into force in July 2017 aims to harmonise grid-use charges in Germany by 2023 and to gradually remove regional differences. In addition, the costs incurred from avoided grid fees will be gradually removed. The slow removal will lead to a moderation of distribution grid costs and thereby help stabilise energy prices.

The coalition agreement between the CDU, CSU and SPD emphasises the utmost importance of accelerating grid expansion and optimising existing grids in making the energy transition a success.

Grid expansion	Expanding and modernising grids to meet demand.

12.1 Expansion of the transmission systems

The expansion of the extra-high voltage grid infrastructure is of central importance to the success of the energy transition and to Germany reaching its climate goals. As renewable energy expands and nuclear energy is phased-out, electricity is increasingly produced and consumed in separate geographical areas. Therefore, the swift expansion of the power grids at the transmission system level is essential, particularly in order to transport the electricity derived from offshore and onshore wind, which is primarily produced in the north and east, to the power consumption hubs in the south and west of the country. Many residents and regions are directly affected by these massive grid projects. The Federal Government decided to make these "electricity motorways" more acceptable to the public by designing most of the lines as underground cables and not overhead lines. In addition to the lengthy process of grid expansion, the grids must be optimised and strengthened in order to increase capacity for electricity transport in the short term.

The expansion of the transmission systems is also a must if we are to make the European internal energy market a reality. European electricity trading boosts the efficiency of the power supply system and increases security of supply. With supply and demand balanced over larger areas, it also enables, inter alia, the cost-effective integration of renewable energy. Besides the domestic expansion of the grid, sufficient cross-border grid capacities are also needed for a functioning internal electricity market (see Chapter 3).

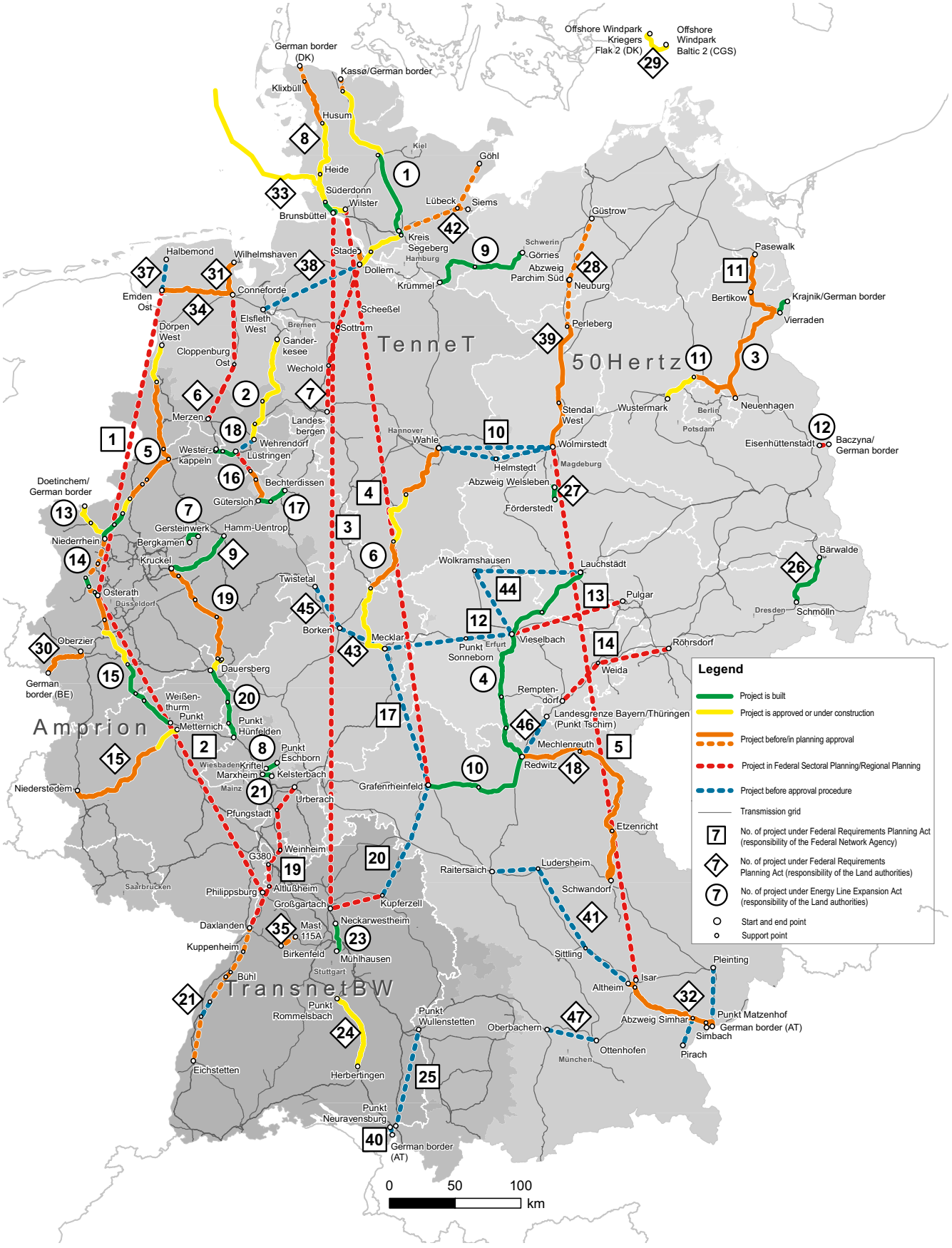
The Power Grid Expansion Act has defined the requirements for the construction of new power lines. Currently the Power Grid Expansion Act comprises 22 projects which were categorised as urgent as early as 2009 (see Diagram 12.1). Taking into account the Federal Network Agency's third quarterly report for 2018, the total length of the lines under the Power Grid Expansion Act amounts to around 1,800 km. The Federal Network Agency continuously documents the current state of infrastructure planning and construction projects. At the end of the first quarter 2018, around 1,100 km, or well over 60% of the projects had been approved. Around 750 km, which corresponds to 40% of the entire length have already been completed. Transmission system operators estimate completion of almost 70% of the total length under the Act by 2020. The expansion projects act as the baseline for calculations in the Grid Development Plan. The Thüringer Strombrücke (Thuringia electricity network) went online in September 2017, closing an historical bottleneck between Thuringia and Bavaria. It serves above all to transport electricity generated from wind in Northeast Germany to Southern Germany.

The Federal Requirements Plan in the Federal Requirements Planning Act of 2015 is based on the projects of the 2024 Grid Development Plan that have been approved by the Federal Network Agency. The swift expansion of renewable energy requires further expansion of the grid beyond the projects under the Power Grid Expansion Act. The Federal Requirements Plan currently comprises a total of 43 projects, 16 of which are categorized as interstate or cross-border projects. The total length of the lines under the Federal Requirements Planning Act is currently at around 5,900 km. In the Grid Development Plan, 3,050 of this amount is categorised as network reinforcement and about 2,850 as new construction. Of the projects, a total of around 500 km had been approved and 150 km of that completed by the end of the first quarter 2018. Formal federal sectoral planning began in May 2018 for the newly planned high voltage direct current transmission lines (HVDC lines) SuedLink and SuedOstLink. Commissioning is slated for 2025. Federal sectoral planning for the A-Nord project was initiated in early 2018.

Underground cabling has priority for HVDC transmission. The Act to Amend Provisions of the Law Governing Power Line Construction gives priority to the planning principle of underground cabling in federal sectoral planning for new HVDC lines. This prioritisation concerns the major north-south power line route projects – SuedLink and SuedOstLink – as well as the northern part of Corridor A. With this approach, legislators are addressing concerns regarding large-scale overhead power lines. The aim is to increase local acceptance for the projects and speed up the expansion of the grid. The coalition agreement between the CDU, CSU and SPD also emphasises acceptance by the public as an important factor for accelerating grid expansion.

The 2017 Renewable Energy Sources Act introduced grid expansion areas for onshore wind energy and a minimum quota for offshore wind energy for the Baltic Sea. These are initial steps to better orchestrate grid expansion and growth of renewables. The expansion of wind energy will temporarily be adapted locally in areas with high grid congestion. In these areas, the volume put out for auction for onshore wind facilities will temporarily be limited - until the end of 2019 - to 58% of the average capacity added for the years 2013 to 2015. This helps relieve the strain on the transmission system and avoid further increases in grid congestion. The remaining expansion amounts are distributed across the other regions in Germany. In the case of offshore wind, the annual auction volume is distributed as follows: 500 MW in 2021 and 2022, 700 MW in 2023 to 2025 and an average of 840 MW from 2026 onwards. This seeks to ensure a continuous deployment path while also guaranteeing that the necessary connection lines for transporting electricity are already in place when new offshore wind turbines commence operation. Furthermore, additional capacity construction for 2021 is focussed on the Baltic Sea. These measures relieve the strain on the grids.

Diagram 12.1: Projects under the Power Grid Expansion Act and the Federal Requirements Planning Act



Source: Federal Network Agency, March 2018
Note: Graphic representation of the state of development of line expansion projects under the Power Grid Expansion Act and the Federal Requirements Planning Act as of 31 March 2018. The lines on the map merely represent the connections between the legally defined grid connection points (straight lines) and should not be interpreted as the visualisation of the power line routes.

Transparency and participation: The public should be strongly involved in grid expansion

The public is closely involved in the grid expansion planning process. This applies to demand assessment, federal sectoral planning and planning approval procedures. For example, transmission system operators and the Federal Network Agency make draft grid development plans available for public consultation. In each case the public has the opportunity to submit written opinions concerning these plans. In addition to participating in these formal procedures, the public can also get involved in informal dialog processes at an early stage. For example, the TSOs and the Federal Network Agency organise numerous local events. In addition, since 2015 the Federal Ministry for Economic Affairs and Energy has been promoting the Civil Dialogue on the Power Grid initiative, which has ten citizens' advice centres nationwide, hosts a wide range of events in the local region, provides online information about its services and offers formats for participation.

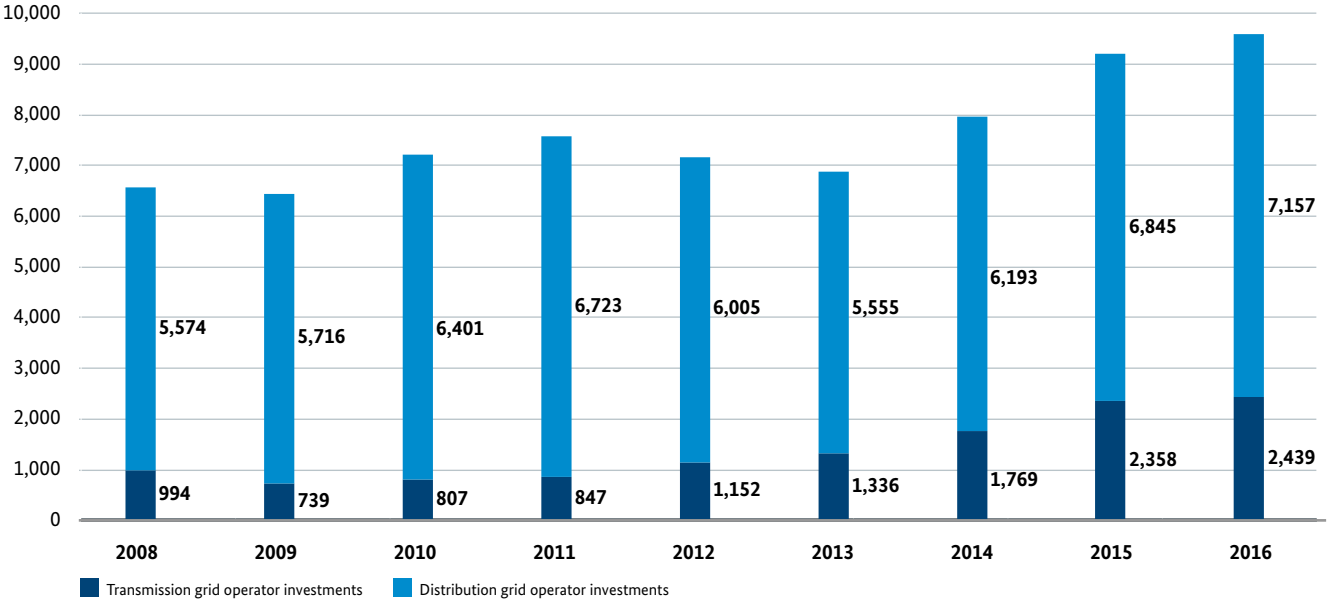
Regular, comprehensive monitoring of the expansion projects creates transparency for all stakeholders on the progress of the infrastructure projects. The Federal Network Agency publishes a quarterly monitoring report. While this previously focussed on projects under the Power Grid Expansion Act, changes were introduced starting in 2016. Since then the Federal Network Agency has also documented the state of implementation of projects under the Federal Requirements Plan Act and projects under the Offshore Grid Development Plan, i.e. the connection lines for offshore wind farms, in the form of a report and on www.netzausbau.de. In the Power Grid Expansion Act reports and the Federal Requirements Planning Act reports, as of the fourth quarter 2017, projects are also marked either as grid expansion or grid reinforcement projects. As of mid-2018, monitoring will also include measures for optimising existing networks (e.g. using available grid monitoring or high-temperature conductors). Applying Directive 2007/2/EC can also assist in creating geographic information bases in connection with power line routes and thereby increase transparency of grid expansion and network optimisation.

12.2 Expansion of the power distribution grids

Power distribution grids increasingly face new tasks. Traditionally, the role of power distribution grids is to distribute electricity locally within a limited region. Increasingly, these grids have to contend with new challenges. For example, feed-in to the distribution grid is increasing, because over 90% of installed capacity from renewable energy installations are connected to it, and more and more energy consumers are also electricity producers. Because the distribution grids are not designed for such electricity feed-in, however, there is increased need for investment. The improvement of electro mobility will present new challenges to the expansion of the power distribution grids.

The use of digital technologies plays an important role in the modernisation of the distribution grids. So that distribution grids can manage the new challenges described in the foregoing, they must be made smart grids. Conventional electricity grids become smart grids when they are fitted with communication technology, instrumentation and control technology and IT components. In this manner, grids can be connected intelligently, and grids and can be connected intelligently with electricity generation and consumption. To this end, the Bundestag adopted the Act on the Digitisation of the Energy Transition in July 2016. The SINTEG funding program was started at the end of 2016, with a total of five showcase regions that try out innovative processes, technologies and business models for consumers,

Diagram 12.2: Investment in new construction and expansion, maintenance and restoration of power grids
million €



Source: Federal Network Agency, October 2017

storage and grid operators. This real laboratory on digitisation of the energy world should collect insights on further development of the legal framework (see Chapter 13.2).

12.3 Grid investment and grid charges

The expansion of the power grids requires greater investment. Continued growth in investment is also expected in the future. Investments of network operators into German electricity grids (see Diagram 12.2) have increased, as have expenditures for maintenance in 2016, to a total of €9.6 billion. Inter alia, this comprises costs for financing underground cabling, which is funded through grid-use charges and borne by end users. Most of the investment in the transmission grid – about €2.1 billion – went to new grid construction and grid reinforcements. Further to this, €366 million were spent on grid maintenance and repair. At the distribution grid level, grid operators invested around €3.7 billion in the expansion and €3.5 billion in the maintenance and repair of the infrastructure.

The costs for the operation, maintenance and expansion of the power grids are financed by grid charges, which are borne by the grid users. Grid charges averaging 6.79 ct/kWh were levied in 2016 to supply domestic customers drawing between 2,500 and 5,000 kWh annually. When considered in relation to the average electricity price of 29.80 ct/kWh this is equivalent to a 22.8% share in the price. Grid charges in 2016 increased on the previous year, rising 3%. For industrial customers with an annual offtake of 24 GWh that are not covered by special compensation arrangements, grid charges went down by 2.8% to 2.06 ct/kWh in 2016, with the result that the share of grid charges in the electricity price amounted to 14.5%. On the reference date, 1 April 2017, grid charges for household and industrial customers went up.

Grid operator revenues are subject to the incentive regulation. The power grid is a natural monopoly. The Federal Network Agency and Land regulation authorities protect electricity consumers from any monopolistic abuse. According to the regulatory framework, grid operators can only use the grid charge to refinance costs that would be incurred under efficient management conditions. To this end, before the start of the regulation period, an individual revenue cap is set for each grid operator for every year of the regulation period. This should allow grid operators to generate sufficient revenue to cover their actual costs taking efficiency requirements into consideration. The revenue cap is a determining factor for the grid charge amount. The incentive regulation was reformed in August 2016 with the aim of improving investment conditions, boosting incentives for efficiency and increasing transparency.

The Network Charges Modernisation Act that entered into force in July 2017 gradually reduces regional disparities in grid charges and creates more distribution equality. To this end, the transmission grid charges will be aligned starting in 2019, in five steps. As of January 2023, the charges for transmission networks will be the same everywhere in Germany. To ensure this, the Federal Government in April 2018 adopted the Ordinance on the Gradual Introduction of Uniform Federal Transmission Grid Charges. The Bundesrat,

Utilise the potential offered by optimising the existing grid

In order to reduce costs of network congestion problems in the transmission grid, in early 2017 the Federal Ministry for Economic Affairs and Energy launched a comprehensive stakeholder process together with the Federal Network Agency, the German Energy Agency, BET Aachen, associations and companies, and worked out an action plan (dena, BET 2017). The work group developed seven measures in addition to expanding the grid, that should lower economic costs and improve utilisation of the electricity grid in the short term. This includes optimal grid monitoring and structural improvements to five sections of the transmission grid, especially installation and upgrade to high current cables. These measures should be implemented by 2023. The stakeholders involved expect to achieve a significant reduction in costs in net network congestion management by implementing these measures. The transmission grid operators place this savings potential at more than €200 million annually.

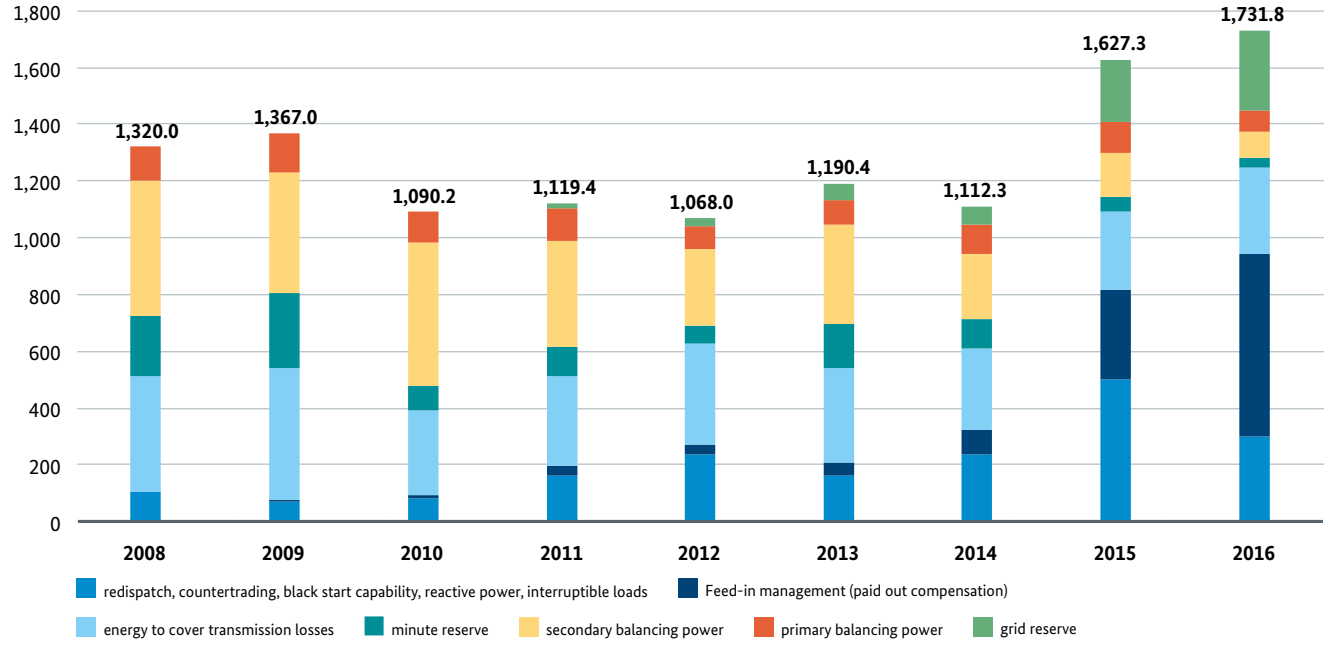
the upper house of German parliament, approved of the bill in June 2018. In addition, the Network Charges Modernisation Act stipulated that payments made by distribution network operators to power producers for avoided grid fees will be gradually removed. This could lead to a palpable slowing of the increase in network costs, especially in the north and the south of Germany. Cost development from 2017 to 2018 provided specific evidence of this. This development will benefit power customers.

12.4 The stability and quality of the power grids

The grid operators are responsible for the stability of the power grids. To keep the grids stable, the grid operators rely on certain measures, known as ancillary services, for example in the event of frequency or voltage fluctuations or grid bottlenecks. For example, balancing capacity is used to correct frequency deviations. Grid congestion is handled by redispatching conventional power stations and managing the feed-in from renewable energy plants. Generally speaking, producers of renewable electricity, as well as storage systems and flexible demand, will also need to contribute more to system stability in the future. Grid operators can already use interruptible loads today, for example.

Under the German Energy Agency's Platform for Ancillary Services, grid and plant operators, technology manufacturers and the Federal Ministry for Economic Affairs and Energy are working together on solutions for the further development of grid stability measures. From 2014 to 2017, the Platform placed recommendations for action in impor-

Diagram 12.3: Costs for ancillary services
million €



Source: Working Group on Energy Balances, Federal Network Agency 10/2017

tant political debates, initiated research projects and encouraged major participants to exchange knowledge. Now it is important to continue active work on this basic transformation process, especially in order to set reliable conditions that would ensure an alternative way to provide ancillary services in an energy system with a high renewables percentage. The dena Ancillary Services Platform will continue to assist in this process.

Costs for system services increased slightly in 2016, at €1.7 billion, compared with €1.6 billion in the previous year (see Diagram 12.3). This results in average costs of 0.34 cent per kilowatt hour of electricity consumed, 0.03 cent more than the previous year. The costs for ancillary services are borne by electricity customers largely through the grid charges (see Chapter 10). The share of ancillary service expenses that can be attributed to congestion in the power grid (especially redispatch, feed-in management and grid reserve) has increased slightly from €1.0 billion in 2015 to €1.2 billion in 2016. It is important to keep in mind that the 2016 costs also included compensation paid for feed-in management giving rise to claims in previous years (2014, 2015). In contrast, the amount of energy amount curtailed by feed-in management in 2016 went down by 20% – that is, on the whole, fewer installations were curtailed. One reason for this is that the wind was relatively weak in 2016. Costs for frequency and voltage level maintenance for common types of energy dropped in 2016 compared to the previous year, by 37% to €198 million, also because less balancing energy is needed in a functioning electricity market.

Central measures for the grid infrastructure

- Network Charges Modernisation Act (NEMoG)
- revision of the Incentive Regulation Ordinance
- Act to Amend Provisions of the Law Governing Power Line Construction
- continued development of the monitoring of German grid expansion projects
- further development of the Ordinance on Agreements Concerning Interruptible Loads
- Electricity Market Act (see Chapter 9)
- Act on the Digitisation of the Energy Transition (see Chapter 13.2)


MARKET
TECHNOLOGY
BUSINESS
DIGITAL
CONNECTION

13 Integrated development of the energy system

Where do we stand?

The economically efficient integration of the electricity, heating and transport sectors contributes increasingly to decarbonisation, greater efficiency and a more flexible energy system. The importance of heat pumps for heat generation has increased dramatically.

Digitisation links the energy sector with modern information and communication technology. Digitisation uses innovative, customer-friendly business models to create new potential for efficiency improvements and for integrating renewable energy. Data protection and data security are a high priority in this regard.

What is new?

The Act on the Digitisation of the Energy Transition entered into force in September 2016, and was the kickoff for the smart grid, smart meter and smart home technology in Germany. This infrastructure project connects electricity consumers and producers using smart metering systems in a smart grid and can trigger investments in the billions.

The BMWi conducted consultations in the summer of 2016 for its Green Paper on Energy Efficiency and the “Electricity 2030” discussion paper. The topics here were how sector coupling and digitisation can contribute more in the future to the success of the energy transition.

Sector coupling **Digitisation**	Unlocking the potential of efficient sector coupling and digitisation for a successful energy transition.

13.1 Coupling the electricity, heating and transport sectors

Renewable electricity is becoming the most important source of energy. The demand for energy that remains after tapping existing efficiency potential and using renewable energy directly in the heating and transport sector will increasingly be covered by the efficient use of renewable electricity (sector coupling). In the transport sector, this will be accomplished, in particular, through the roll-out and uptake of direct-electric drive technologies based on a power supply increasingly derived from renewables. In the buildings sector, alongside other renewable energy sources electricity from renewables is playing an increasingly important role in the heating supply, e.g. through the use of heat pumps. Considering the limited amounts available, sustainably produced renewable fuels (e.g. biomass) will be employed where the use of electricity is not technically or economically feasible. This can apply to the aviation or shipping sectors, in particular, and to some parts of industry. However, it is still cheaper to use fossil fuels for transport and heat than for electricity. In order to reach the long-term goal of a nearly carbon-free energy supply, it is increasingly important to further reduce overall energy demand with cross-sectoral efforts ("Efficiency First" principle) and to make the power system even more flexible. The Federal Government plans to encourage sector coupling for the heat, transport and industry sectors and to modify the regulatory framework to include use of "green hydrogen" and hydrogen as the product of industrial processes for fuels, or for producing conventional fuels (e.g. natural gas). Efficient use of renewable electricity is expected to provide an important contribution to decarbonisation. To achieve this, the framework must be adapted.

High-efficiency heat pumps and electric vehicles require comparatively little electricity and can make a major contribution to decarbonisation and efficiency improvements in the heating and transport sectors. As Table 13.1 illustrates, both these technologies need less electricity to generate the same quantity of heat or propulsion energy than conventional fossil fuels or technologies involving several conversion steps.

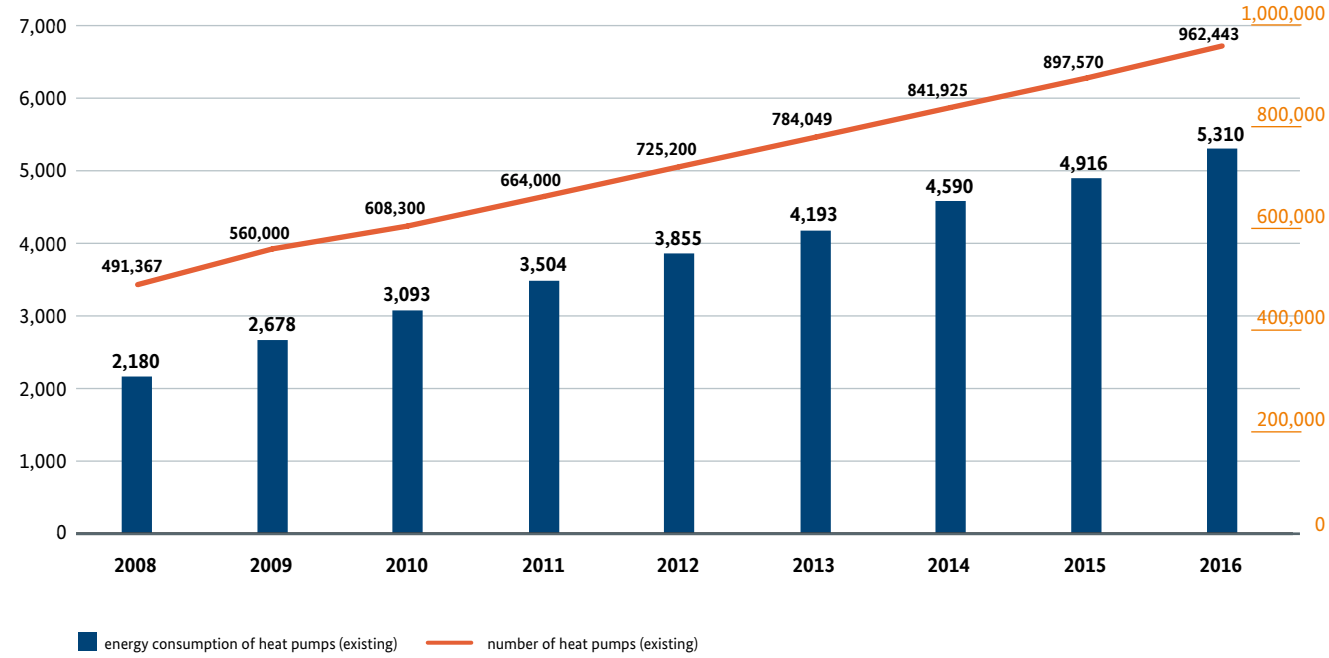
The importance of heat pumps for heat generation has increased dramatically in recent years. Since 2008, the number of installed systems has risen from less than 500,000 to over 960,000. This is attributable both to the continuous reduction in the cost of the systems and to regulatory minimum requirements with regard to renewable energy and energy efficiency (e.g. Energy Conservation Ordinance, Renewable Energies Heat Act), as well as funding programmes (e.g. CO_2 Building Modernisation Programme, Market Incentive Programme). Over the same period, the

Table 13.1: Different quantities of fossil fuels replaced by different sector-coupling technologies with one kilowatt hour of electricity (in the heat supply and transport sector)

regenerative energy supply			savings in fossil energy		substitution ratio
input	technology	energy or use provided	technology	input	
1 kWh regenerative electricity	Power-to-Heat heat pump	3.3 kWh of heat	condensing boiler	3.1 kWh of natural gas	**3.1**
1 kWh regenerative electricity	e-vehicle	4.6 km	combustion engine	2.6 kWh of diesel	**2.6**
1 kWh regenerative electricity	Power-to-Heat dielectric	1.0 kWh of heat	condensing boiler	0.9 kWh of natural gas	**0.9**
1 kWh regenerative electricity	Power-to-Gas (hydrogen) residue	0.7 kWh hydrogen	steam reforming	0.9 kWh of natural gas	**0.9**
1 kWh regenerative electricity	Power-to-Gas (methane)	0.6 kWh methane		0.6 kWh of natural gas	**0.6**
1 kWh regenerative electricity	Power-to-Liquid	0.5 kWh of liquid fuel		0.5 kWh of liquid fuel	**0.5**

Source: Federal Environment Agency (2016a) and (2016b)
The calculations in the sources are based on plausible assumptions. The values in the table have been rounded off.

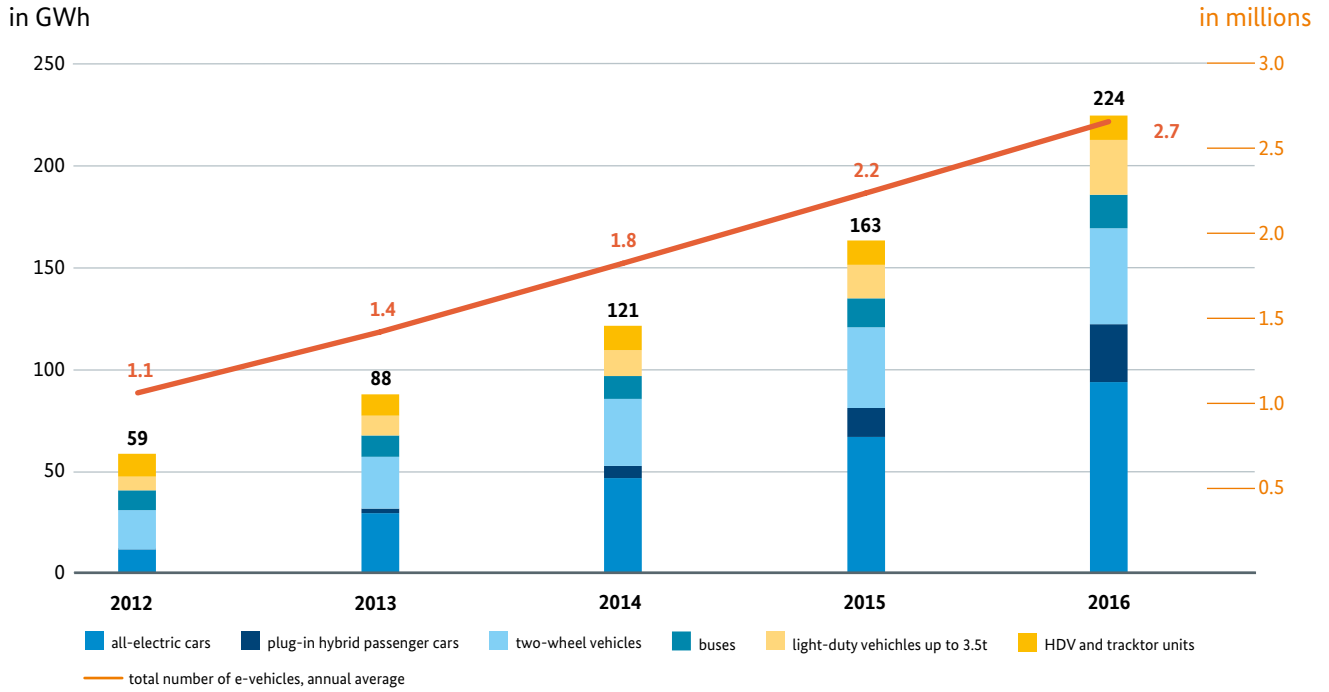
Diagram 13.1: Quantity and electricity consumption of heat pumps
in GWh



Source: Federal Environment Agency/Working Group on Renewable Energy Statistics based on data from the Centre for Solar Energy and Hydrogen Research and the Bochum Geothermal Centre, 12/2017

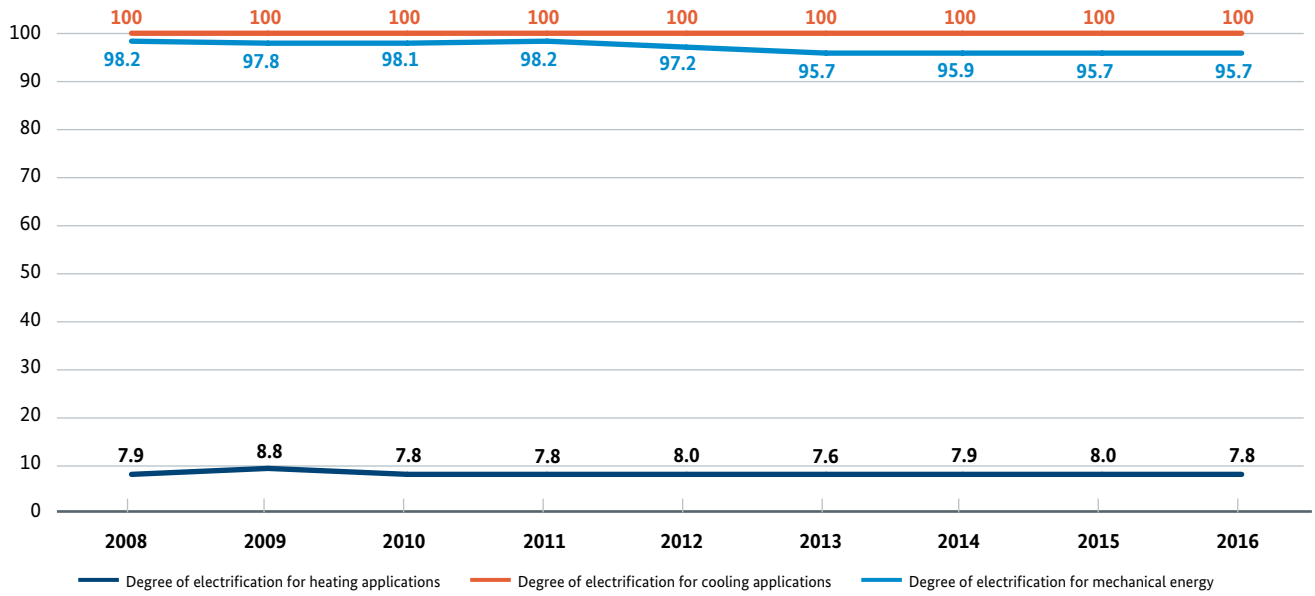
installed thermal capacity also grew by a factor of 2.5, from 3,964 MW to 10,009 MW. This is because the increasing numbers of pumps being installed are also increasingly bigger and more powerful. The development of the electricity consumption of all heat pumps has been largely in step with the thermal capacity, and stood at roughly 5.3 TWh in 2016. In 2016 the share of heat pumps in heating systems in new accommodations was 23%, according to the Working Group on Energy Balances; however, this share for existing accommodations was only 1.8% for electric heat pumps (see Chapter 6: Buildings for information on heating systems). More R&D is needed to optimise the installation and use of heat pumps.

Diagram 13.2: Quantity and electricity consumption of two-wheel and three-wheel-plus electric vehicles
in GWh



Source: Federal Environment Agency's TREMOD model 5.65 5/2017, includes all-electric drives and plug-in hybrids

Diagram 13.3: Degree of electrification of industry
in %



Source: Working Group on Energy Balances, 11/2017

The number of electric and plug-in hybrid vehicles on German roads rose again in 2016. Having said that, with the exception of the rail sector the electrification of vehicle drives in Germany is still in its infancy (see Chapter 7). Nonetheless, electricity consumption deriving from electric mobility using two-wheel and three-wheel-plus vehicles increased in 2016 by around 37% to roughly 224 GWh compared with the previous year (see Diagram 13.2). Due to the increasing share of renewables in the electricity sector, transport-related final energy consumption from renewables also increased. However, calculations made using the Federal Environment Agency's TREMOD model show that electricity consumption for the rails between 2008 and 2016 dropped by about 4%. The Federal Government is committed to ensuring further progress is made in the field of alternative drive technologies (see Chapter 7.2).

The share of electricity in final energy consumption of industry remained relatively constant in the past few years, and at 815 PJ was around 32% in 2016. In the years under study there has been no major change in the structure of energy consumption according to area of application or energy source. Whereas the degree of electrification for cooling uses has remained unchanged at 100% over the years, and for mechanical applications at 96%, the share of electricity in heating applications hovered around 8%. This type of industry process still uses primarily gas, followed by coal. Power consumption of the industry in 2016 of 815 PJ is broken down into 69% (566 PJ) for mechanical applications, 18.2% (144.1 PJ) for heating and 4.3% (35.3 PJ) for cooling.

The integrated development of the energy system will drive forward coupling of the energy, transport and buildings sectors as well as industry, in combination with storage technologies (see Chapter 14.1). Municipal utilities and distribution system operators have a key role by virtue of their connections to utility companies and consumers and with local public transport. The goal is to design a framework such that development of various energy infrastructures – including existing gas and heating infrastructures for sector coupling – is coordinated and cost efficient. Alongside this, flexible infrastructures also play a central role.

Central measures in the area of sector coupling

- Electric mobility eco-bonus (see Chapter 7)
- Promotion of heat pumps
- Low-temperature heat networks with seasonal thermal energy storage
- Promotion of innovative CHP systems under the CHP Act

13.2 Digitisation of the energy transition

The funding program Smart Energy Showcases – Digital Agenda for the Energy Transition (SINTEG) created a real laboratory for the smart energy supply of the future. In five showcase regions smart networks of generation and consumption as well as market and grid are being developed and demonstrated. The solutions that survive real situations are to be later introduced to large-scale application and knowledge gathered in the process is to be used for refining the regulatory framework (see page 147).

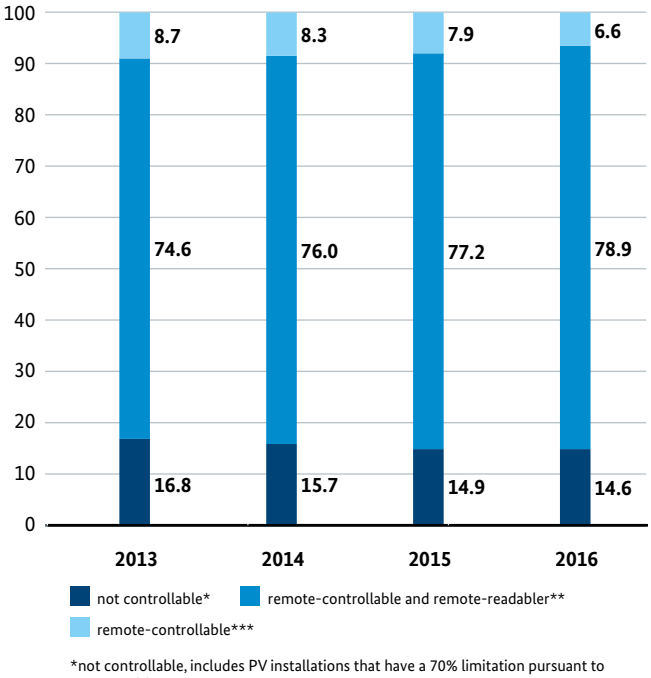
In October 2017 the Federal Ministry for Economic Affairs and Energy launched the project Digitisation of the Energy Transition: Barometers and Main Topics. The project was awarded to three companies (EY, BET and WIK) and will provide assistance for digitisation of the energy infrastructure that will ensue from introducing smart metering systems. The project is set to run three years. An annual barometer provides an overview of progress of implementation. In addition, expert reports are prepared on major issues (Main Topics), such as: How can digitisation make consumers become participants in the energy transition? Which business models does a digitised energy landscape offer? How can grid regulation based on the Metering Act provide additional impetus to flexibilise the grid-based energy supply and coupling of the heating and transport sectors? Are the telecommunications structure and regulation ready for the smart grid? Presentation of the expert report and the Barometer is scheduled for autumn of 2018. There is an advisory board for the Barometer that includes experts from various sectors; in addition, the Working Group on Smart Grids and Metres of the Energy Grids Platform is closely tied into the overall project. The Barometer with its energy industry focus will reflect and drive the digitisation process in accordance with the Act on the Digitisation of the Energy Transition (GDEW).

The required technology will be the focus of the Roadmap for Standardisation Strategy for Transsector Digitisation in accordance with the GDEW. Safe and efficient digitisation of the energy sector requires a standardisation strategy. The Metering Act, part of the GDEW, facilitates the stage by stage expansion of smart meter gateways to additional applications such as the grid functions for feed-in and load management and electric mobility. As stipulated in legislation, the BMWi and the BSI will publish a Roadmap for Standardisation Strategy for Trans-sector Digitisation in accordance with the GDEW, which will contain a specific work programme for all areas covered by the Act. Drafts have already been prepared and the Smart grids and Metres Working Group of the Energy Grids Platform has been introduced to the BMWi. The process led by the BMWi will establish a standardisation strategy for market participants that encourages innovation and helps to create a safe digital system architecture for the smart grid.

Digitisation affects all levels of the value chain in the energy industry – generation, grids, trade, supply and consumption. The goal is a networked value chain. Smart networks and management of generation and consumption based on innovative digital technologies are the essential factors for launching the digital transformation of the energy sector. One overarching trend is the availability of increasingly larger volumes of data, known as big data. This results in new analytical approaches – for instance to identify sustainability potential. However, a priority must also be placed on data protection and security. The GDEW contains the necessary tools and will introduce a transformation of infrastructure in the scope required for the energy transition. Previously, digitisation was carried out at a sector level.

In particular, larger installations for the generation of renewable energy are usually already equipped with information and communication technology. The roll-out of smart meter gateways (SMGW) as set forth in the GDEW will improve integration of power plants into the smart energy grid using the BSI standards; the focus of efforts to expand these standards and the regulatory framework will be on monitoring functions based on the SMGWs.

Diagram 13.4: Remote read and remote control capabilities of RES installations
by installed capacity in %



*not controllable, includes PV installations that have a 70% limitation pursuant to Section 9 (2) Renewable Energy Sources Act 2014,
**remote-controllable, remote-readable RES and CHP plants pursuant to Section 9 (1) Renewable Energy Sources Act 2014,
***only remote-controllable plants pursuant to Section 9 (2) Renewable Energy Sources Act 2014

Source: Federal Network Agency, November 2017

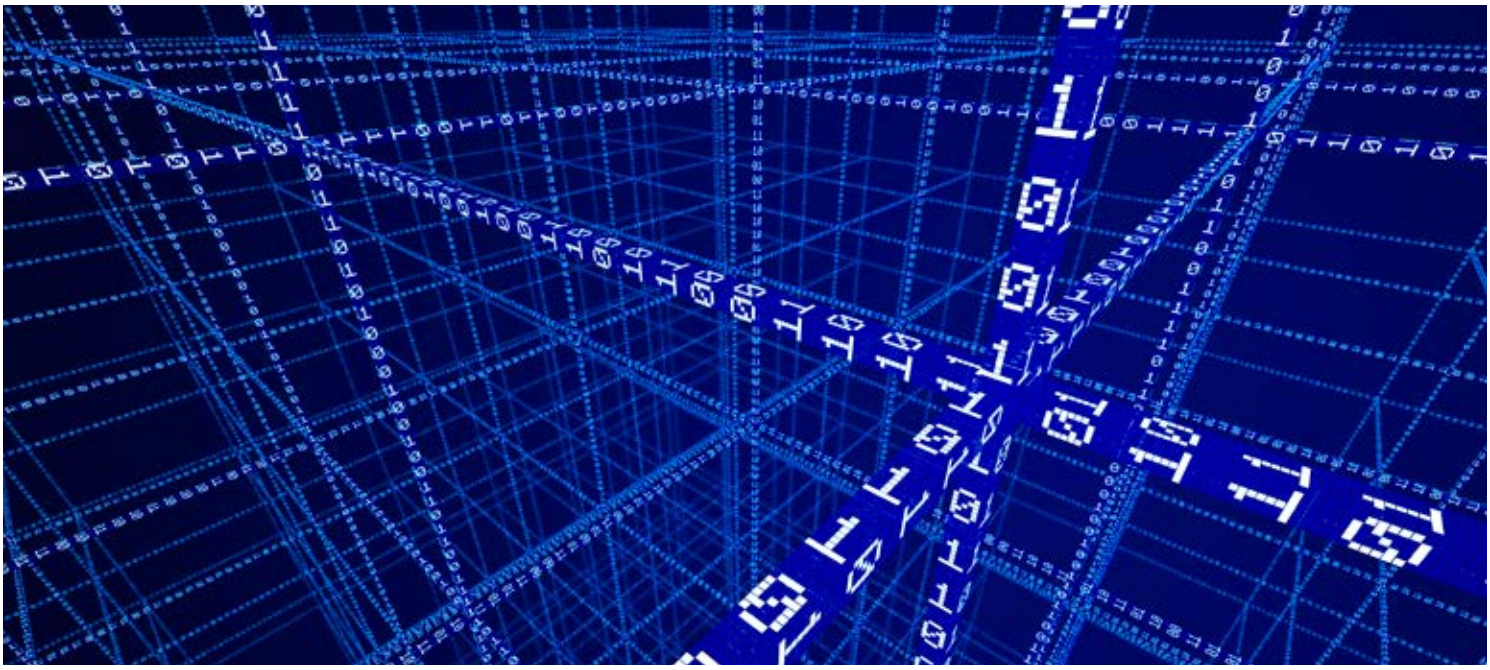
To ensure the optimum integration of renewables with their fluctuating properties into the electricity system, it is important to be able to access information about capacity at all times, and to adapt the capacity if necessary. In 2016, almost % of installed renewable capacity could be controlled and read remotely (see Diagram 13.4). Only 14.6% of the installed capacity did not have remote-control capabilities. The amount of remotely monitored and metered output went up in 2016 for the third time in a row – by about 5% over 2015. If we consider the number of plants with remote-control and remote-reading capabilities, instead of the installed capacity, the result is a share of around 7%, while more than 76% of plants were not controllable. This is because general peak shaving applies for the majority of smaller PV installations, instead of fitting the installations with a system for remote reading and control.

Power grids can be interconnected and also linked to power generation and consumption using smart, modern technologies. Conventional electricity grids become smart grids when they are fitted with communication technology, instrumentation and control (I&C) technology and IT components. The Act on the Digitisation of the Energy Transition that entered into force September 2016 provided the basis for this infrastructure modernisation. In particular, a smart grid results in better utilisation of the existing infrastructure, reducing the need for grid expansion and improving grid stability. According to a 2014 study commissioned by the Federal Ministry for Economic Affairs and Energy, new grid planning approaches and smart grid technologies can reduce the costs of the expansion of the distribution grids expected through to 2032 by up to 20% (E-Bridge, IAEW, OFFIS 2014).

Greater flexibility in the distribution grid. The existing mechanism for creating flexibility in the distribution grid will be modernised, an important component of making the energy transition cost effective. The goals are in particular to create efficient management of grid network congestion and to react to the effects of new loads (e.g. electric cars charging simultaneously, heat pumps, etc.) on the power grids. Electricity today is generated in nearly two million power plants, many of them decentralized. The task of managing power flows and the balance between supply and demand with increasingly fluctuating renewable energy being fed in is increasingly complex. Digitisation facilitates monitoring and control of energy generation, transport and consumption in real time. The Main Topic #2 of the Digitisation Barometer serves to integrate new loads efficiently into the distribution grid.

Digital infrastructures give rise to innovative funding business models in the area of commerce and distribution. These infrastructures play a central role in the market integration of renewable energy. For example, to qualify for the market premium under the Renewable Energy Sources Act (see Chapter 4) renewable energy facilities need to offer remote-control capabilities. Remote-control capabilities give plant operators and direct sellers the technical means to ramp down feed-in or curtail the facility if the situation on the market so requires. In this way, they integrate renewably generated electricity into the market and relieve the burden on the EEG surcharge compared against plants in the system of fixed feed-in tariffs.

Digitisation also enables improvements in energy efficiency through innovative funding business models and the provision of better information to consumers and planners. New possibilities of analysis and user information become possible. On this basis, it is possible to develop energy efficiency services, which – in this format – were previously technically and organisationally impossible or too expen-



SINTEG: Support programme "Smart Energy – Digital Agenda for the Energy Transition"

In **five large showcase regions** involving over **300 companies** and other participants, the SINTEG programme develops and demonstrates solutions for technology, economic and regulatory issues posed by the smart energy system of the future. The focus is in particular on safe and efficient processes that can be used on a wide scale, innovate technologies and market-based mechanisms for flexible smart grids and markets. The main emphasis is **digitisation of the energy sector**.

Another goal of the programme is also to collect practical experience for the future development of the legal framework. To this end the Federal Government concluded the **SINTEG Ordinance**, effective 21 June 2017, which includes time-limited Experimentation Options. The Ordinance provides SINTEG participants the opportunity to test technologies, processes and business models without economic drawbacks, for example for digitisation and electricity-heating sector coupling. SINTEG thus becomes a **Real Laboratory** for a smart energy supply of the future, and the Federal Government gains insight tested in the real world on future adaptation of the legal framework.

The BMWi is sponsoring the five SINTEG showcases with over €200 million. Together with additional investments from the participating companies, a total of over €500 million is being invested in digitisation of the energy sector.

The projects were launched on 1 December 2016 and 1 January 2017, and run for four years. The five showcases each have their own thematic focus:

- **C/sells: Large-scale showcase in the Solar Arch in southern Germany:** The 'C/sells' showcase spans the states of Baden-Württemberg, Bavaria and Hessen, and focuses on solar, with emphasis on the regional optimisation of energy generation and consumption. Its aim is to construct a cellular energy system – cells – that is, autonomous regional cells that act in concert in a supra-regional association. These cells will access the over 10,000 smart metres in planning with the requisite gateway infrastructure.
- **Designnetz: A modular concept for the energy transition – from isolated solutions to an efficient energy system of the future.** The 'Designnetz' showcase in North Rhine-Westphalia, Rhineland-Palatinate and Saarland seeks to use decentralized energy (mixture of solar and wind power) to supply energy to urban and industrial consumers. Local, regional and supra-regional interaction in energy generation and consumption is being tested. The heterogeneous showcase region allows for simulation of nearly all supply services for 2035 in all of Germany.
- **enera: The next big step in the energy transition:** The 'enera' showcase in Lower Saxony address the three topics of grid, market and data. Regarding grids, technology of the energy system should be made more flexible with upgrades or new installations at the generation, consumer and storage level, and by reinforcing the grid with new equipment. In the area of market and trade, the EPEX electricity exchange should add to its order books in the intraday market any information on the power generating facilities sites. An adequate digital infrastructure must be created to ensure that this trading runs smoothly. Goals include regional ancillary services that stabilise the grid locally. In the planning is a grid with more than 30,000 smart metering systems and sensors that will be linked to the communication network.
- **NEW 4.0: The energy transition in the north of Germany**: From the electricity transition to the energy transition: The aim of the 'NEW 4.0' showcase in Schleswig-Holstein and Hamburg is to demonstrate that it will be possible to supply 70% of the entire region's energy demand from renewable sources by 2035 – in a way that is both secure and reliable. In the scope of a twin-track strategy, regional curtailments of wind-powered installations in the model region should be counteracted by higher electricity exports to other regions. At the same time, becoming energy independent, that is, producing renewable energy for regional consumption should be increased with useful flexibility options and sector coupling.
- **WindNODE: showcase for smart energy from the north-east of Germany:** The WINDNODE showcase spans the five eastern German states plus Berlin. It aims to efficiently integrate renewable energy generation in a system spanning all energy sources and comprising the electricity, heating and mobility sectors. All participants in a future smart energy system are represented in WindNODE – producers, consumers, grids, markets – and cooperate to enhance flexibility. The focus of this project is the perspective of the user. Nine demonstrators present innovative applications at all levels of the smart energy system, and are linked into one main model.

SINTEG receives support from an evaluation research consortium, in particular to increase the outreach of the programme, to facilitate knowledge transfer on a national and international level and to connect these levels, to support norm and standards processes and for evaluation.

SINTEG is part of the Innovative Digitisation of the German Economy package used to implement the Federal Government's Digital Agenda.

sive. For example, the Energy Savings Meter pilot programme, which was launched in May 2016, promotes innovative and IT-based pilot projects to reduce energy consumption using energy services that are based on the digital collection and processing of energy consumption data. In addition, digitisation allows for new types of organisation and control of industrial manufacturing processes (Industrie 4.0) for optimising energy input.

The digitisation of planning processes in buildings, known as building information modelling, or BIM, supports energy optimisation and enables clear, transparent solutions for all processes in a facility that are relevant from an energy standpoint. The smart networking of energy meters and consumers in buildings can result in the efficient use of energy, while also increasing user convenience and comfort (smart home). Digital applications in the transport sector can ensure better vehicle-to-vehicle connectivity and the better networking of vehicles with the transport infrastructure and the energy system. This can contribute to a more efficient transport system and to the optimum integration of electric vehicles into the energy system (see Chapter 7).

The digital transformation of the economy and, moreover, the digitisation of industrial production processes along the entire value chain – known as Industry 4.0 – present enormous potential to make production processes more energy-efficient and climate-friendly and to thereby make a major contribution to the energy efficiency goal of the energy transition. The Federal Government supports these efforts with funding programmes for investment in modern sensing technology, software, hardware and smart efficiency solutions. Specific programme examples include Autonomics for Industry 4.0, E-Energy, Climate-smart Production Processes, SINTEG and Copernicus projects for long-term research questions (see Chapter 14).

When it comes to measuring energy consumption in industry, meters that support remote automatic meter reading (AMR) have been standard equipment in many areas for quite some time, however, this technology did not previously need to meet BSI standards on secure communication, which will change with the Act on the Digitisation of the Energy Transition. In the case of domestic customers, digital applications to reduce energy consumption are still not very common. For example, electricity meters that support remote AMR are still very rare in domestic households: only around 2.3% of the 51 million plus domestic meters can be read remotely. Roughly 85% of all meters in the domestic sector are still traditional electromechanical meters, known as Ferraris meters. The trend is electronic metering devices, which increased by almost 40% from 2015 to 2016. The number of electromechanic meters declined slightly, by 2.3% (see Chapter 13.5).

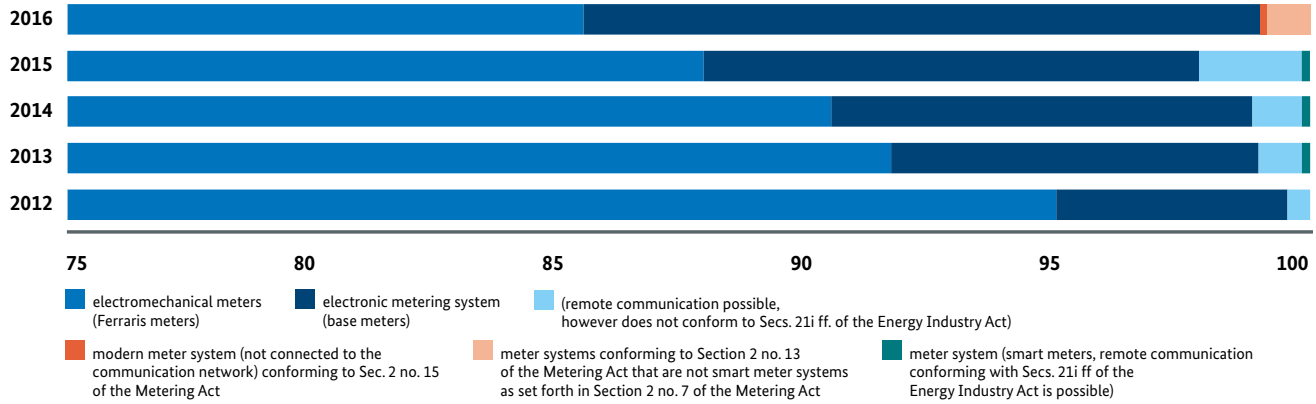
Data protection, data privacy and reliable standards are basic prerequisites for the successful digitisation of the energy transition. The Act on the Digitisation of the Energy Transition aims to satisfy these requirements. Energy consumption data must be increasingly protected to prevent abuse and to guarantee consumer privacy as the pace of digitisation picks up. In addition, it is also necessary to prevent the energy system from becoming increasingly vulnerable to hacking and virus attacks during the further course of the digital transformation. Therefore, the implementation and certification of suitable protection measures is a decisive factor in order to guarantee security of supply, even as the degree of digitisation increases, and to prevent economic damage.

The digitisation of the energy transition has begun. With the Act on the Digitisation of the Energy Transition and the SINTEG programme (Smart Energy Showcases – Digital Agenda for the Energy Transition), the Federal Government

Blockchain – Potential and Challenges

The blockchain is also being tested in the German energy sector, for example by transmission system operator TenneT and Sonnen, a battery storage system manufacturer. Plans are to connect up to 6,000 photovoltaics home storage systems by mid-2016, to create more flexibility in the electricity grid. For example, if wind energy and solar PV installations generate more power than is needed at a specific time, this excess energy can be stored for the interim in a home storage network. If there is no wind and no sun, the storage energy can flow back into the power grid and to consumers. The storage facilities are connected by blockchain so that it can be determined exactly which storage unit stored how much energy and when and how much it again released. This is important in particular for accounting, because participants may consume the additionally stored energy without charge. In contrast to the “Brooklyn Microgrid”, however, the focus is not on exchanging electricity between prosumers, rather stabilization of the power grid. It is currently not possible to project whether blockchain applications can also be used after the pilot project to support the energy transition on a large scale. The results up to now have been encouraging.

Diagram 13.5: Metering and measuring technology used in the domestic customer sector
% of total meters



Source: Federal Network Agency, October 2017

has taken important steps towards defining the framework for digitisation in the power sector. Work on this path to smart grids, smart meters and smart homes must be rigorously continued. Applications in these areas benefit from a communication platform modelled after the principle Data Protection and IT Security By Design. This platform includes transparent rules for data communication. The Federal Ministry for Economic Affairs and Energy and the Federal Office for Information Security are developing standards for a smart meter gateway for the aforementioned areas. Work plans will be part of a 'Standardisation Strategy Roadmap for Cross-sector Digitisation in accordance with the GDEW' (Act on the Digitisation of the Energy Transition). This will also benefit businesses outside of the energy sector.

The results of consultations on the Green Paper on Energy Efficiency and the Electricity 2030 discussion paper of the Federal Ministry for Economic Affairs and Energy also demonstrate how digitisation can contribute to the success of the energy transition and reaching energy policy goals. To assist in the digitisation process, it is especially important to utilise the potential that the GDEW provides for creating smart grids for an affordable energy supply. Innovative business models will be tested in model regions and results compiled to determine how to adapt the legal framework (SINTEG). This should help integrate flexible utilities and consumers into the distribution network. After all, consultations have demonstrated with a large consensus that digitisation opens up new possibilities for value-added services and efficiency services.

Central measures in the digitisation of the energy transition

- Act on the Digitisation of the Energy Transition (GDEW)
- 'Digitisation of the energy transition: Barometer and Main Topics' project
- Standardisation Strategy Roadmap for Cross-sector Digitisation in accordance with the GDEW
- 'Smart Energy Showcases – Digital Agenda for the Energy Transition' (see box)
- Energy Savings Meter pilot programme (see Chapter 5.4)
- Expanding federal funding programmes for market introduction of the climate-friendly smart Efficiency Plus Building Standard, because these buildings of the future will take on an additional function of "smart energy managers" (network and notification of energy use in and around a house and in the urban quarter)

14 Energy research and innovation

Where do we stand?

Energy research is the key to a successful energy transition. In 2016, €876 million were mobilised as part of the Federal Government's 6th Energy Research Programme, with three-quarters of the funds channelled into the renewable energy and energy efficiency research fields.

This federal research program puts emphasis on renewables, energy efficiency and energy system technologies (grids and storage).

What is new?

In view of the challenge of increasing integration of renewables into the energy system and coupling of the sectors electricity, heat and transport, the focus of the energy transition is on overarching initiatives such as Solar Construction / Energy-efficient Cities, Energy Transition in the Transport Sector, and the Copernicus projects.

In the autumn of 2018, the 7th Energy Research Programme will be launched. Consultation with stakeholders has been concluded. The evaluation of these consultation sessions, conducted in 2017, show which research topics are at the forefront, including sector coupling and digitisation.

Research Innovation	Fostering forward-looking innovations for the restructuring of the energy supply.

14.1 Research and Development

The research, development and demonstration of innovative energy technologies is first and foremost the challenges of the business sector. Besides supporting basic research, public-sector research funding generally also aims to support applied research, technological developments and innovative activities in the business community, research institutions and universities.

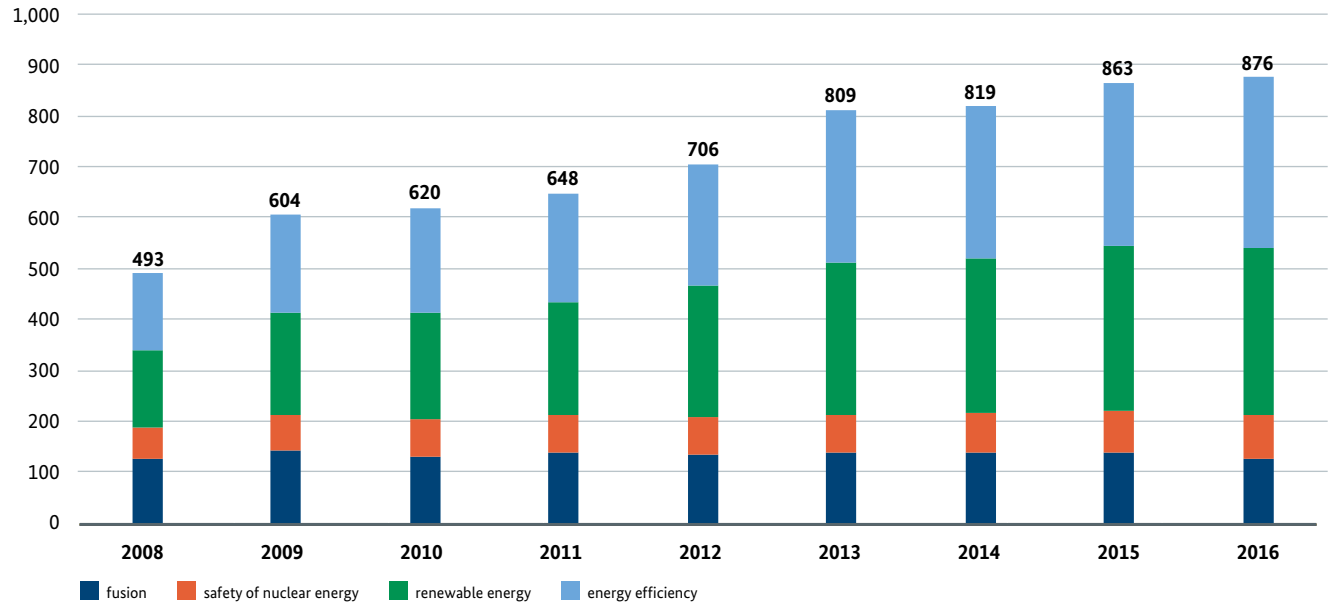
Apart from research funding, however, support in the form of suitable policy frameworks is also essential to make innovative technologies cheaper and marketable. This involves regular changes to regulatory law, as well as specific measures to support the transfer of research and market preparation. The coalition agreement provides support for the transition from research to demonstration and market introduction and in addition, to create more Real Laboratories (e.g. power-to-gas or power-to-liquid technologies) as an additional pillar of energy research. A topic of particular interest in the coalition agreement is low carbon industry processes.

Business investment in research and development for innovative energy technologies continued to increase in 2016. Within the framework of publicly funded energy research projects alone, businesses invested around €155 million in the development of innovative energy technologies in 2016. Added to this are third-party funding payments to universities and research centres as part of collaborative projects. The total volume invested by the business community in the research and development of energy technologies is probably far higher than this.

Industry-oriented energy research safeguards the competitiveness of German industry. The focus of applied research and technological development is on industry-led projects conducted in close cooperation with research institutes and universities. In total, industry participated in 54% of all current research projects on applied energy research. Industry also committed €252 million to newly approved research projects.

The Federal Government again increased the budget for energy research in 2016. From 2013 to 2016, the Federal Government provided a total of about €3.6 billion to promote the research and development of modern energy technologies. In 2016, €876 million were mobilised as part of the Federal Government's 6th Energy Research Programme. This corresponds to an increase of 1.5% over last year, nearly doubling the amount in ten years (see overview in Diagram 14.1). Funding for energy research is in high demand, and is popular with companies and research institutes. In 2016, 92% of the funding set aside was paid out. About three-fourths of the annual budget wen to energy efficiency and renewable energy. The annual Federal report on energy research gives a comprehensive overview of all major developments. In this way, the Federal Government creates transparency on funding policies of energy research and provides information on which energy technologies are being promoted.

Diagram 14.1: Federal Government research spending in the Energy Research Programme
million €



Source: Federal Ministry for Economic Affairs and Energy, 4/2016

Since the beginning of project assistance in 1977 (1st Energy Research Programme), the Federal Government has invested around €12 billion in funding non-nuclear energy research. EnArgus, a new, centralised information system provides a comprehensive overview of federal energy research programmes over the past 40 years.

Horizon 2020, the European research and innovation framework programme, is given high priority in Germany. Of the total budget of approximately €80 billion for the Horizon 2020, around €6 billion are earmarked for non-nuclear energy research projects (see 2017 Federal Report on Energy Research). Funds amounting to around €675 million were available for the area of energy in 2016. Of the projects approved, some 14% of this European funding will go to Germany.

The increasing complexity of R&D leads to deeper knowledge-sharing at the international level. Germany is involved in many facets of international cooperation in energy research. At present, Germany is actively involved in 22 of the 38 current IEA Technology Collaboration Programmes (TCP). The "Mission Innovation" initiative was launched at the 21st session of the Conference of the Parties to the Framework Convention on Climate Change in Paris (COP21) in December 2015.

The fact that there is a consistently high outflow of funds from an annually growing budget underlines the key importance of energy research for implementing the energy transition. Energy research creates the technology basis for conversion of the energy supply system and is a strategic element of federal energy policy.

Cross-sectoral energy research makes a central contribution to the energy transition. The focus of energy research is increasingly trained on the importance of the integration of the electricity, heating and transport sectors (sector coupling) and the integration of innovative technologies into the system to deliver on the goals of the energy transition (see Chapter 12). Interministerial research initiatives into storage systems, grids, the buildings and urban quarters areas, hydrogen and fuel cell technology will be continued and, going forward, will potentially incorporate new activities looking into smart sector coupling within the context of the energy transition using electricity-based fuels.

Transparency and participation: Examples from energy research

Energy research networks
To transfer the results energy research directly to the protagonists of the energy transition and to support the dialogue between the scientific community, business and government funding policy, the BMWi has initiated seven research networks since 2015 focused on major funding priorities:

- Construction for the energy transition
- Power grids
- System analysis
- Renewable energy
- Energy efficiency in industry and commerce
- Flexible energy conversion
- Biomass energy use

As the interface between research, practice and policy-making, the networks help to provide subject-specific guidance for funding strategies with a practical orientation, and to coordinate new measures. This also puts transparency and efficiency at the centre of energy research. The Energy Transition Research and Innovation Platform (R&I platform) brings together and coordinates the energy research networks, which are established on a long-term basis.

Consultation on the 7th Energy Research Programme
Consultation on the 7th Energy Research Programme began in December 2016 and was concluded in 2017. The broadly designed consultation procedure involved all important participants in energy research and the energy sector at an early phase in discussing future energy policy. The goal was to realign funding policy strictly to the goals of the energy transition and to exploit successes. By keeping an open approach to the participatory process, transparency and an open dialogue were made possible. The evaluation of these consultation sessions shows the entire research needs, but also which overarching research topics are new priorities, in particular sector coupling and digitisation.

Energy Transition Research Forum
The research projects of the four Copernicus projects (grids, storage, industry processes and system integration) were identified in the Energy Transition Research Forum in a comprehensive participatory process with over 90 institutions and organisations from the scientific community, business and the public.

The four project consortia being sponsored combine participants from the scientific community, business and the public. This real example of practiced, early involvement of the public in research is a major thrust of the projects.

Energy research will become even more important going forward. This positive trend will continue and will strengthen the role of energy research in the context of the Federal Government's energy policy. Medium-term financial planning will provide for €1.105 billion for project funding in 2020. In the European context also, Germany will continue to push for a holistic approach geared towards the transformation of the energy system.

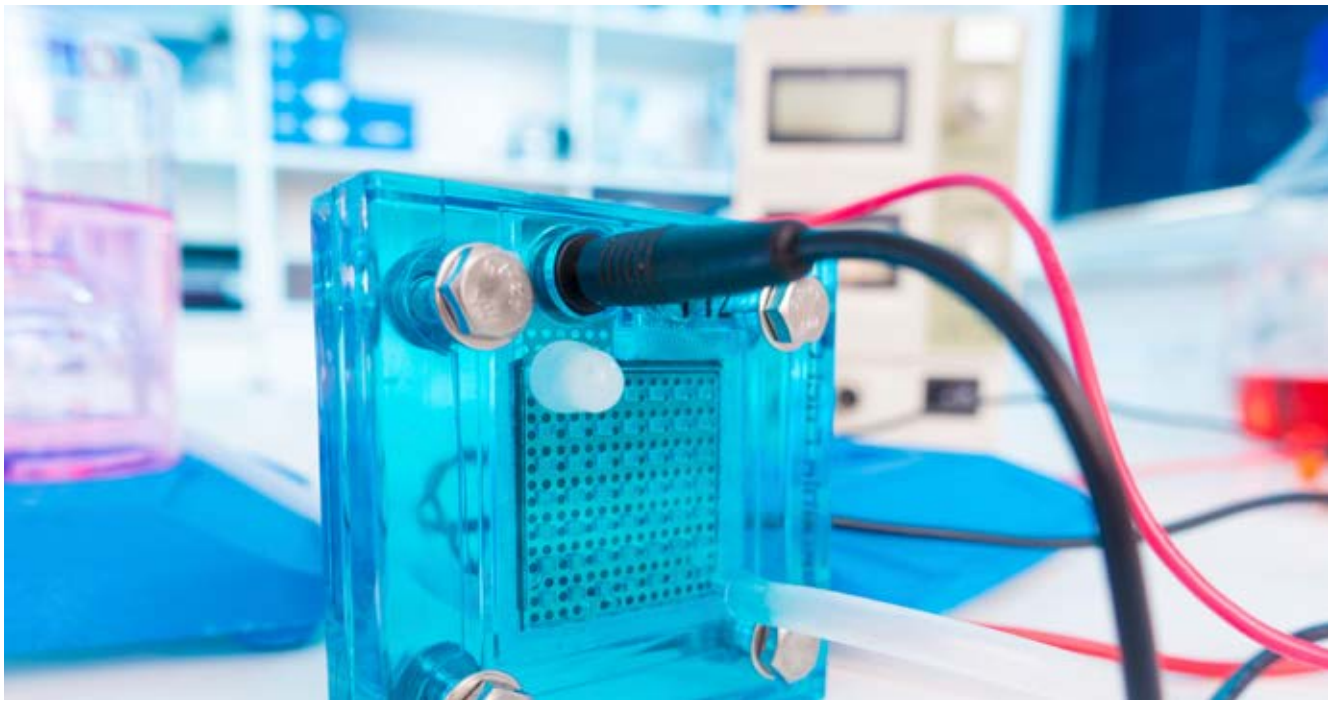
14.2 Innovative energy technologies

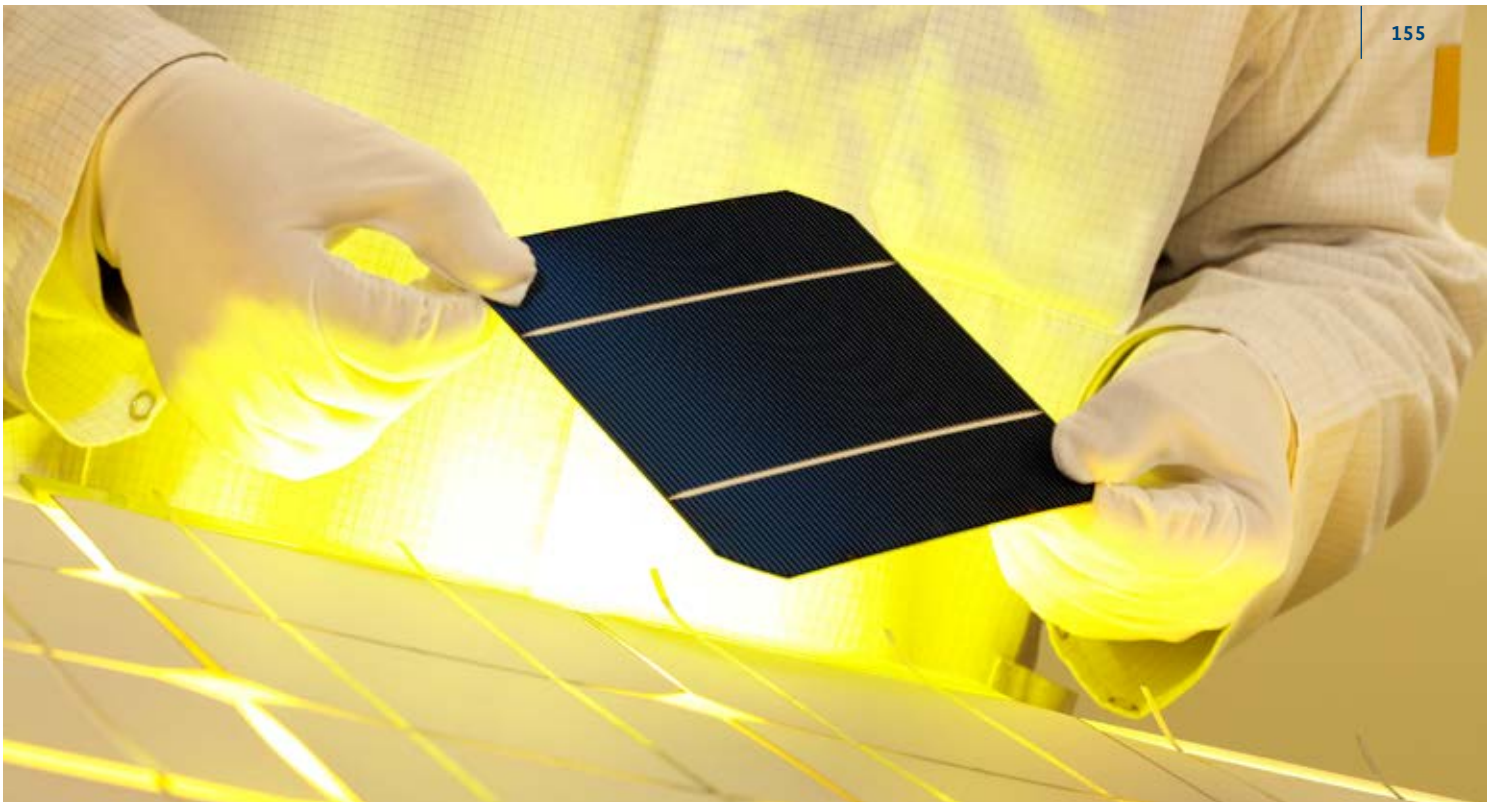
Promising results of research are the basis for new, low-cost and marketable energy technologies. As illustrated below, examples of the growth of innovative technologies that are characterised by greater efficiency, lower costs or resource conservation can be found across the board in all areas of the energy transition.

The number of patents filed in the area of renewable energy are testament to the high level of innovation in this field. In 2016, 1,139 patents were filed in the area of renewable energy (DPMA 2017). However, continuing the trend of the past two years, the number of both domestic and international filings dropped again (-17.3% compared with 2015). The majority of filings – a total of 68.7% – were submitted from abroad. Patents, however, are just one of many facets of innovation and therefore are not an indicator in their own right. More decisive is to what extent new products actually come into use and bring economic benefit. The number of patents cannot provide this information. In addition, the rate of patent applications varies greatly in different technological disciplines.

The patents filed in the area of automotive engineering are a reflection of innovative transformation processes. Patent applications for hybrid and electric drives have more than doubled since Year 2009 (German Patent and Trademark Office 2017). Overall, the number of patents filed for combustion engines still exceeds the number of patents for alternative drives. However, the rise of 19% in filings for purely electricity-driven vehicles in 2016 is worth noting. In particular, the growth in the number of patent applications filed by companies registered in Germany (+46.5%) and Japan (+28.7%) is significant. The Federal Government is committed to ensuring further progress is made in the field of alternative drive technology (see Chapter 7).

Technological advancements and innovations in RES technology in the field of power generation are driving down costs. This applies in connection with the enormous growth in market volume and economies of scale, especially for photovoltaics and increasingly, for wind energy. While the remuneration rates for PV for small roof-mounted installations were over 50 ct/kWh Year 2007 ago, they now stand at around 12 ct/kWh for roof-mounted installations and below 10 cent for PV ground-mounted installations not part of competitive pricing processes. The average contract prices are much lower for PV ground-mounted installations and large roof-mounted installations from the bidding rounds of 2017. Within the 9-month period between January 2017 to October 2017, the average contract price dropped by 30% to below 5 ct/kWh. Similar cost reductions indicate the results of the first bids for onshore wind energy. The average contract price from the bidding rounds in 2017 sank within 6 months by one-third (see Chapter 4).





Energy storage is becoming increasingly important with the continually growing share of renewable energy in the energy supply. If electricity is converted before being stored, for example into hydrogen or other chemical energy sources, in addition to being reverted to power, there is the possibility for use of this energy in other sectors, in the sense of coupling. Up to now, however, only a few storage technologies have achieved the requisite maturity regarding competitive cost. The Federal Government has invested around €184 million in funding since 2011 in development of various storage technologies for the energy transition. The last projects of the joint Energy Storage funding initiative conducted by the BMWi and the BMBF will be concluded in 2018. Hydrogen, batteries and heat accumulators for distribution of energy loads are the technology paths to be taken in the future for network-oriented, stationary energy storage. The Federal Government is developing customised funding activities as part of its Seventh Energy Research Programme, and supports a large range of storage technologies with its projects. It will continue to address new storage ideas and press ahead with technological developments already begun.

The priorities in R&D are increasingly shifting toward making power plant processes more flexible as the increasing integration of renewable energy in the electricity market has given rise to new requirements. Research activities in this area create the framework to ensure that Germany's power plant fleet can better meet these requirements in future.

Central measures in the area of energy research

- Consultation on the 7th Energy Research Programme
- Energy transition - Research and Innovation platform (R&I platform)
- Energy Research Networks
- 'Energy transition in the Transport Sector' research initiative
- 'Energy-efficient Buildings 2050' funding initiative
- 'Solar Construction/Energy-efficient Cities' funding initiative
- 'Sustainable Power Grids' research initiative
- 'Energy Storage' research initiative
- National Hydrogen and Fuel Cell Technology Innovation Programme (NIP 2) for the 2016 to 2026 funding period
- Copernicus projects
- 'Energy Systems of the Future' Academies' project
- Energy Transition Research Forum
- Biomass Energy Use funding programme
- Renewable Resources funding programme
- Programme collaboration: Energy Transition Research Alliance at the German Federation of Industrial Research Associations (AiF)
- 'Carbon2Chem' research initiative
- Mobility2Grid and Flexible Electrical Networks research campuses

The trend towards products with the highest energy efficiency ratings continues. Energy-efficient technologies and devices experienced increasing popularity again in 2016. The EU eco-design and the EU energy labelling system continue to make a central contribution to this development. The new EU Ordinance on Energy Consumption Labelling entered into force on 1 August 2017, stipulating a shift from the A+++ to A-G labelling, as well as introducing a product database (see Chapter 5, Energy Labels).

Energy efficiency continues to be the focus of building modernisation measures. Efficiency developments in energy retrofits funded through the CO_2 Building Renovation Programme are evidence of this. In addition, incentives to use renewable energy in the heating market were strengthened once more with the reform of the funding guideline for the Market Incentive Programme that entered into force on 1 April 2015 (see Chapter 6). The market share of efficient condensing boilers also expanded significantly in the heating and warm water sector in 2016. Furthermore, the share of electric heat pumps is also increasing continuously (see Chapter 12.1). Other generators of heat, such as biomass and solar thermal, are also part of the market (see Chapter 6).

There is an increasing number of electric and other alternative vehicle drive systems among the new passenger cars registered each year. By the end of 2016, 30 German automotive manufacturers had 30 models in series production (see Chapter 7). There is still room for efficiency improvements in fossil fuel-based vehicles. To this end, the New Vehicle and System Technologies programme was launched. Vehicles with hydrogen-powered fuel cells and natural gas-powered vehicles are a mature technology and are available (see Chapter 7).

The power-to-X technology market is still in the phase of operation of demonstration facilities. Power-to-X and, in particular, power-to-gas or also power-to-fuel technologies, offer promising opportunities to interlink the power generation, gas and mobility sectors both technologically and economically (see Chapter 13.1). While pioneering research projects have helped the technology to make significant progress towards reducing the costs of facilities and components and towards increased flexibility in plant operation, it has not yet been possible to cover the costs of day-to-day operation. Currently, hydrogen manufactured by natural gas reforming is markedly cheaper than green hydrogen, which requires a large amount of energy to generate (generation costs of €1.4/kg compared with almost €6/kg). An expert opinion commissioned by industry reaches the conclusion that to reduce costs, especially of electrolysis plants by more than 50% of current levels will require a market scale-up to at least 1–1.5 GW. Only at this large volume is it possible to made green hydrogen economical and overtake hydrogen produced with natural gas. The cross-sectoral funding initiative Energy Transition in Transport places the focus on manufacture and use of alternative, electricity-based fuels and using new technologies in mobile applications in transport and industry. Both the P2X Copernicus project and Carbon2Chem research large-scale electrolysis systems that can produce hydrogen ecologically from renewable energy at competitive prices.

New market potential from innovation provided by small and medium-sized businesses

The Central Innovation Programme for SMEs (ZIM) is a technology-oriented and sector-neutral funding initiative provided by the BMWi that also sponsors R&D projects in energy technologies. SMEs and research institution that cooperate with these companies receive subsidies for ambitious market-driven R&D projects. In the following examples from the ZIM, the research and development resulting from the projects forms the basis for new digital business models in which SMEs see market potential. They demonstrate the opportunity available SMEs in Germany to open up new business areas and to expand digitisation of the energy transition to the benefit of everyone:

- **Smart Energy Systems in Cities** – Development of a smart energy storage system based on innovative energy management systems for use in cities: A digital energy management system (including a weather forecast) aims to raise the share of renewables in photovoltaics by about 15% to 75%, without additional load to the low-voltage grid.
- **Monitoring power transformers with automatic measurement:** Using Industrie 4.0 methods in the energy sector allows for monitoring large transformers at the ultra-high voltage level using their performance data.
- **Smart energy generation:** Digital solutions for controlling linked local power generation systems and energy storage systems and remotely monitoring them. This maximizes use of the energy generated for self-supply. Specific consumption profiles of local consumers are taken into account.
- **Development of a software module for diagramming resources used in IT processes for energy efficiency in data centres:** A software module has been developed to include energy aspects of IT resources management.

Digital solutions are making their mark across all industries and sectors. This is particularly true with regard to the power sector and grids (smart meter rollout) and the buildings sector (smart home, grid-supportive buildings, see Chapter 13.2). With regard to automated and connected driving, Germany currently leads the way in key technology fields. By implementing the Strategy for Automated and Connected Driving, the Federal Government is creating the framework to exploit the opportunities for growth and prosperity which the mobility system of the future will offer. Automated and connected driving will make road traffic safer and, with increasing market penetration and the gradual optimisation of the flow of traffic, will also reduce emissions caused by the transport sector.

Innovative and highly efficient energy technologies are essential requirements for a secure, economical and climate-friendly energy supply. Only through increased R&D can the German economy continue to maintain a leading position in technology and competitiveness. The coalition agreement between the CDU, CSU and the SPD provides in particular for specific funding for energy research on developing industry processes that are low in CO_2 emissions or on CO_2 closed cycles. One example is the Carbon2Chem project started in 2016 by the Federal Ministry of Education and Research to provide financial assistance for research on a global solution to the economic recycling of blast-furnace gas using renewable energy.

Central measures for the funding the marketing of innovative technologies

- Promotion of stationary fuel cell heating as part of the Energy Efficiency Incentive Programme
- Hydrogen and Fuel Cell Technology Government Programme for the 2016-2026 funding period

Additional examples of innovation funding:

- Energy Efficiency Incentive Programme (see Chapter 5)
- Strategy for Automated and Connected Driving (see Chapter 7)
- Electric Mobility Showcase
- PV Battery Storage Systems funding programme (see Chapter 9)

15 Investment, growth and jobs

Where do we stand?

The energy transition in Germany is part of a macroeconomic modernisation strategy to open up new market potential and to provide tangible impetus for growth and jobs with billions in ongoing investment funding. Innovative business models offer big opportunities in this process.

In 2016 the focus of investing activities continued to be energy efficient refurbishment of buildings and promotion of renewable energy, especially wind energy.

Jobs in the energy sector remained at a high level in 2016 as in past years, and they continued to shift to the renewables sector.

The demand of the energy sector for investment goods as well as the energy efficient refurbishment of buildings also continued to provide the largest number of jobs.

What is new?

In 2016 a number of regulations were adopted to make planning feasible and to create a stable framework for investments in the energy system. This includes the EEG 2017, the Electricity Market Act, the Act on Digitisation of the Energy Transition (GDEW) and the revision of the incentive regulation.

Investment **Growth** **Jobs**	Retaining and creating jobs in Germany and laying the foundations for sustainable prosperity and quality of life.

15.1 Investments

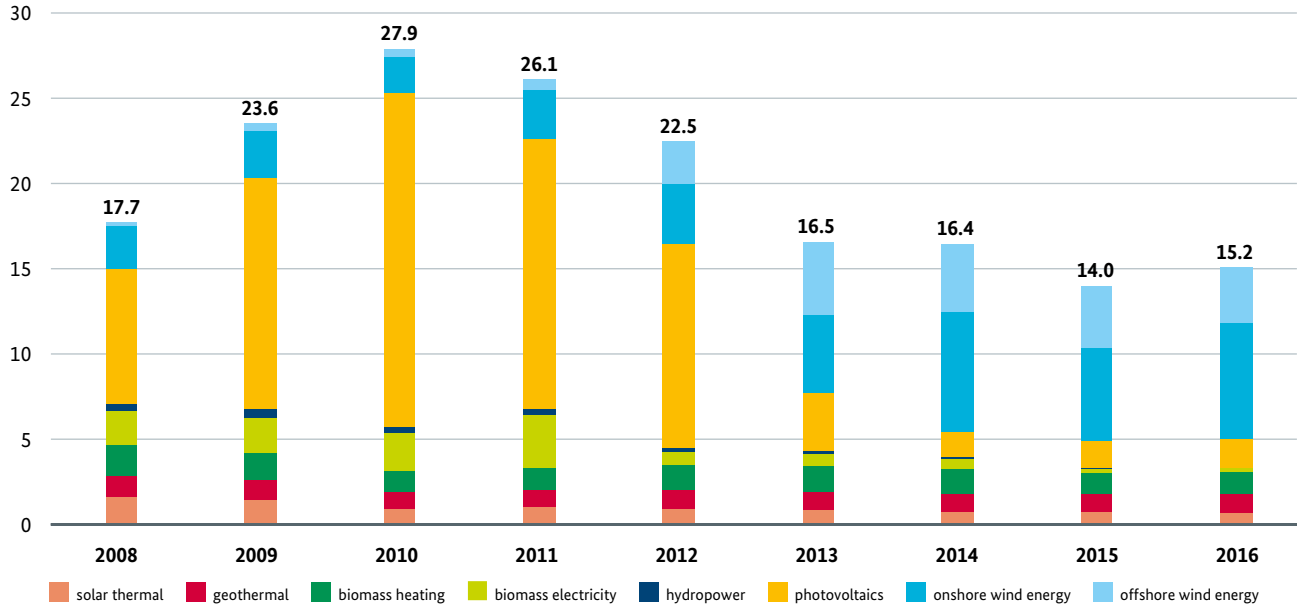
Investments are key to discovering growth and employment possibilities in the German economy and also remaining competitive in the future. Investments in coming years will also determine whether Germany can continue to provide a modern and powerful infrastructure and ensure the success of the energy transition. Economic and energy policies have a considerable bearing on the decisions of businesses and use of innovative business models. Competition between sectors and technologies for energy conversion may produce more new business models and products. The Act on the Digitisation of the Energy Transition adopted in September 2016 paves the way for innovative business models in the field of digital technologies (see Chapter 13). These investments do come largely from private households and companies. In the end, the energy transition is contributing to macroeconomic investment growth in Germany. A clear and stable framework increases investment and planning certainty. This framework was strengthened in July 2016 with the adoption of the Renewable Energy Sources Act 2017 (see Chapter 4), the Electricity Market Act (see Chapter 9) and the reform of the Incentive Regulation Ordinance (see Chapter 12). All the key measures of the National Action Plan on Energy Efficiency (NAPE) and the Immediate Action Programme have since been implemented to encourage more private investment in efficiency technology (see Chapter 5).

As the German energy system is continually converted, investments are made continually and in a substantial amount – this trend continued in 2016. The energy sector comprises provision of fuels, operation and maintenance of equipment for energy generation, storage and distribution, as well as trading in final energy. This includes both fossil and, increasingly, renewable energy sources. In 2016, €24.3 billion was invested in these areas of the energy industry. According to initial estimates, this is more than in the previous year (DLR, DIW, GWS 2018). The largest portion was spent on investments in providing electricity and heat, at €14.8 billion. In 2016 €7.6 billion was invested in infrastructure for distribution of final energy (electricity, gas, heat). The remaining amount went to storage technology (gas, electricity, heating), as well as facilities for providing fuels and motor fuels (coal, petroleum, crude oil and natural gas, as well as biomass and bio fuels).

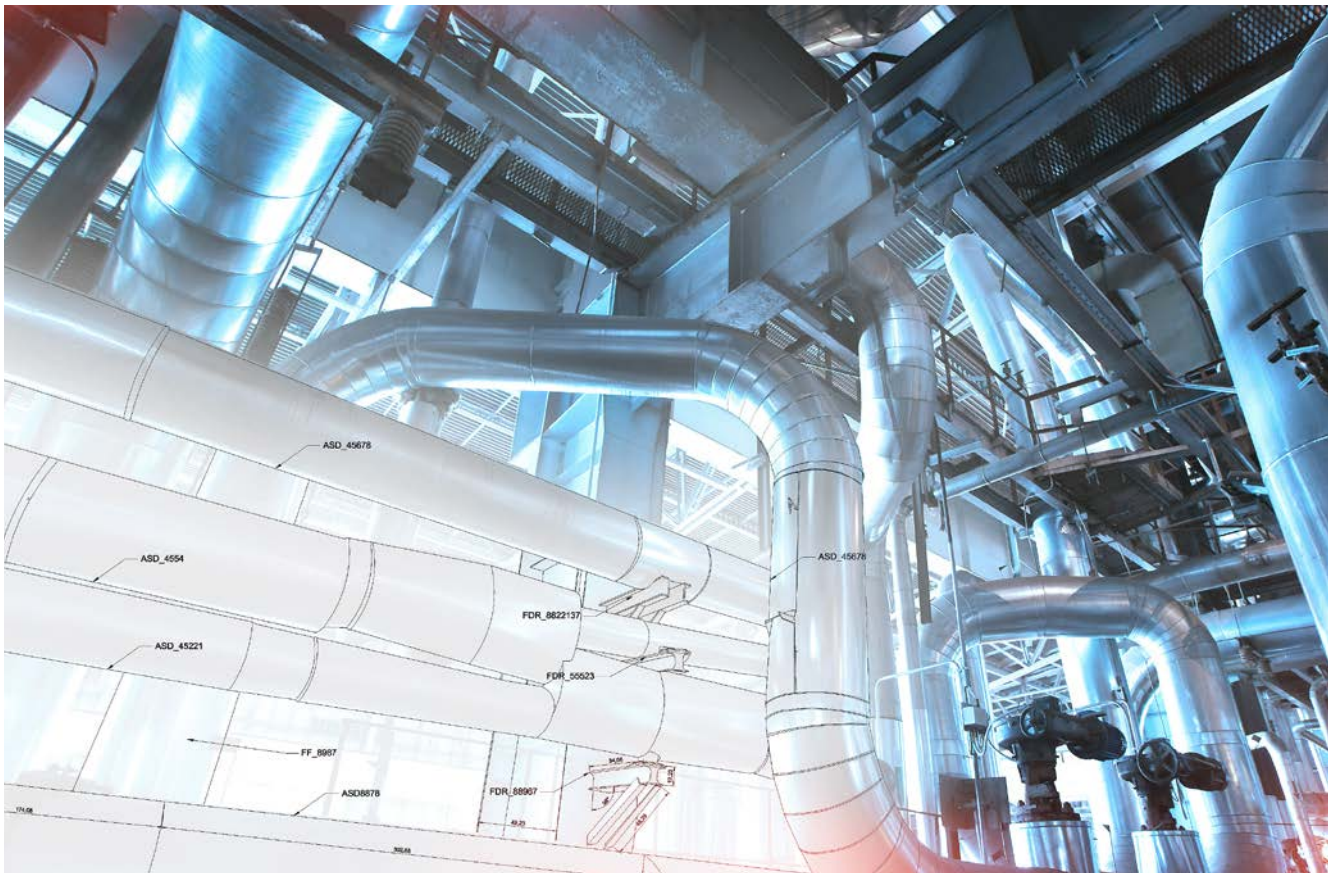
Investment in the power grids remains high. According to numbers provided by the Federal Network Agency, transmission and distribution system operators invested about €5.8 billion in grid expansion in 2016, the same level as in the previous year. According to preliminary figures, this investment level was maintained in 2017 (see Chapter 12).

Investments in construction of installations using renewables once again increased slightly in 2016. At around €15.2 billion (see Diagram 15.1), they were above the 2015 level but below that of previous years. Investments were made especially in electricity generation, but also to a small degree

Diagram 15.1: Investment in renewable energy
million €



Source: BMWi according to the ZSW 2/2018



in generating heat from renewable sources. The moderate growth in investment that brings about relatively significant increases in capacity (see Chapter 4) shows that costs for capacity expansion per installation are going down. Investments are still concentrated on the efficient technologies for producing energy: wind energy and photovoltaics. In 2016 they amounted to 75% of all investment.

Energy transition investments affect not only the energy industry in the strict sense, as illustrated above, rather also the areas of final energy consumption, especially heating and transport. Spending on improving the energy performance of buildings are an important factor. According to the German Institute for Economic Research (DIW) and the Institute of Economic Structures Research (GWS, scheduled for 2018), €42.5 billion were spent in 2016 on this, compared with €39 billion in 2015. Energy retrofitting for buildings is a main focus of measures to increase energy efficiency; information on investments of other areas of energy efficiency is still incomplete or numbers were not current. In 2015, efficiency investments of €0.94 billion were made by production industries.

15.2 Growth

Investments made as part of the energy transition have a positive impact on growth. Owing to the interdependencies of intermediate inputs, these investments have a knock-on effect, generating value add in many areas of the national economy. A current modelling study conducted by GWS and Prognos (scheduled for 2018) compares the current situation with a hypothetical situation without the energy transition. The study concludes that the energy transition increased value added in Germany in 2015 by over €30 billion (approx. 1.3%). We can assume that the effect was similar in 2016. According to the study, Germany's new energy strategy largest contribution to value added was in the area of equipment investments for the energy transition, meaning investments in power plants as well as efficient vehicles, equipment and installations.

The energy transition has led to a moderate increase in macroeconomic price levels. GWS and Prognos (2018) are of the opinion that, as a result of energy transition measures, inflation in Germany was slightly higher in 2015 than it would have been in the absence of the energy transition (since 2005, on average 0.1 percentage points). This development is also understood in the context of overall low inflation in Germany.

German investment goods for the energy transition are increasingly exported. In general, capital goods to help restructure the energy supply system are purchased from suppliers within and outside the country, in varying amounts. As the import quotas for domestic construction services are relatively small – DIW and GWS (2018) estimate annual imports of €1.2 billion – in the past few years in Germany there has been a marked shift from domestic demand to demand outside of Germany for plants and components. In 2016 almost €12 billion of these items were exported, somewhat less than in 2015. The positive export balance was over €6 billion (DLR, DIW, GWS 2018). Furthermore, in 2015, 11% of all globally traded environmental protection and climate change mitigation goods were "made in Germany"; this make Germany the second largest exporter in this category, behind China. All this indicates that German companies still have a leading position in the area of modern energy technologies. Because the energy transition is also being copied in other countries, there are even more export opportunities for Germany, providing impetus for value creation, jobs and innovation.

With more renewable energies and attempts toward energy efficiency, there is less need to import fossil fuels. Germany is not rich in natural resources, and in 2016 imported 98% of petroleum consumed, about 91% of natural gas, and over 94% of black coal. These fossil primary energy sources are continually being replaced with renewable energy resources, which is reducing German demand for imports. In 2016, a total of 551.7 billion kWh of energy from fossil fuels were replaced with the use of renewables in the electricity, transport and heating sectors (BMWi 2017b). Total savings has increased over 2015 by another 7.6 billion kWh. Regardless of the existing energy source mix in Germany, improvements in energy efficiency reduce energy demand in general (see Chapter 5) and accordingly also affect demand for import.

Germany currently covers around two-thirds of its energy needs through energy imports. This considerably exposes the German economy to the often volatile global market prices (see Chapter 10). The prices of these fossil fuels have declined considerably in recent years, thereby relieving the burden on consumers to some extent. However, an important goal is to loosen the dependence on individual suppliers.

The energy transition also contributes to this: The energy shift to put energy supplies on a more sustainable footing has led to fewer fossil fuels imports. The demand for imports of fossil fuels would have been higher in the absence of renewable energy and energy efficiency efforts.

According to GWS (2018), the estimated dampening effect of renewables and energy efficiency on the demand for imports of fossil fuels in 2016 is calculated at €16.1 billion. This means specifically that businesses and households had relatively lower expenditures for energy, savings which were put into personal savings or consumption, or increased corporate profits. Diversifying energy sources and transport routes for raw materials can create similar lasting savings and is therefore also a top goal of the Federal Government.

15.3 Jobs

The job impact of the energy transition affects both the energy sector in the stricter sense and industries that supply the energy sector with goods. These two areas must be considered together. The energy sector comprises a broad spectrum of services, including provision of fuels, operation and maintenance of equipment for energy generation, storage and distribution, up to trading in final energy. Each individual area requires workers. The expansion of renewables and investments in energy efficiency sharpens the focus on the fact that increased demand for capital goods in these areas also leads to manufacturing and job effects in industries outside of the actual energy sector.

Direct employment in the energy industry in Germany has generally remained stable, and areas related to renewables are continues to grow in importance. Official statistics provide numbers on direct employment in classic, usually conventional energy industry. Employment is spread over the areas of electricity generation, transmission and distribution, as well as electricity trading. Added to this are other areas of the energy sector, such as gas and district heating supply, coal mining and production, the extraction of crude oil and natural gas, and petroleum refining. Employment over all areas (adjusted for the overlap with renewables) was at about 218,000 in 2016. And then there are new jobs for operation and maintenance of renewable energy installations – 76,000 in 2016 – and 69,000 for production of biomass and biofuels. Overall, the energy sector employed around 360,000 individuals, which corresponds closely to employment trends observed since 2000 by DLR, DIW and GWS (2018). At the same time, this overall employment figure has shown over time a noticeable shift over time from classic, conventional energy sectors to renewables.

In 2016, 10,000 more jobs were created in renewables compared to 2015; the leader is the wind energy sector. Renewable energy has become an important economic factor, which is evident from the employment figures. Expansion of renewable energies provided around 339,000 jobs in 2016 (DLR, DIW, GWS 2018). In addition to energy generation, these calculations – which include the production of electricity, heat and biofuel – also factor in interdependent delivery and input chains. Due to high investment in onshore wind energy, this area in particular has shown job growth. Consolidation in the photovoltaics sector is ongoing.

Investments in building energy retrofitting employed almost one-half million people. Aside from the energy sector, energy efficiency, especially energy-efficient refurbishment of buildings, is the dominant driver of employment. According to DIW and CWS estimates (publication scheduled for 2018), in 2016 544,000 individuals had jobs related to investments in retrofitting. This affected in particular the construction industry. Additional employment is provided for example by efficiency services, such as energy consulting, energy contracting, energy management or information service activities. According to estimates, at least 44,000 jobs are attributable to these areas (BMWi 2018).

The energy transition is a macroeconomic strategy for modernising Germany as a place to do business. Significant investments in climate-friendly energy and efficient technologies, in municipal infrastructure for electricity and heat networks, in building insulation, storage, electric mobility and much more strengthens the domestic economy and makes Germany competitive and ready for the future. These investments make Germany less dependent on oil and gas imports, give it a lead in R&D and reinforce its status as a major exporting country. By ensuring stable parameters for the energy transition, the Federal Government provides the conditions for maintaining jobs in Germany and for creating a basis for lasting prosperity and quality of life.

16 Overview of measures

	Instrument	State of implementation
	Chapter 3: EU and International Aspects	
1.	Governance Regulation	**Goal:** This proposal for a regulation provides for a new planning and monitoring system for implementing the five dimensions of the Energy Union, especially the 2030 Energy and Climate Framework. To this end, the proposal creates the necessary groundwork for a larger convergence of national energy and climate policies in the various Member States. **Content/Facts and figures:** A major component of the Governance Regulation comprises the integrated National Energy and Climate Plans (NECP) that each Member State must submit to the European Commission by December 2019 (draft by December 2018). They should provide a perspective for the coming 10 years for the national goals and contributions to the EU 2030 Goals in the five dimensions (decarbonisation, energy efficiency, the European internal energy market, supply security and research, innovation and competitiveness), as well as measures for reaching these goals. To create comparability, the Governance Regulation sets exact specifications for the content and structure of the Plan. These Plans should be updated after five years. In addition to the NECP, starting in 2023 the Member States are to submit progress reports; in addition, the European Commission is to monitor the process. This will ensure that the Member States make sufficient contributions with their planned activities toward achieving the 2030 energy and climate goals for the EU, or that adjustments can be made, where appropriate. In the event that voluntary efforts or progress in achieving the EU goals are not satisfactory, the proposal for the Governance Regulation contains in particular concrete rules for additional measures at the EU or Member State level in the area of renewable energy (Gap-filler Mechanism) that should ensure that the joint EU goals are achieved. **Status:** The Governance Regulation is part of the 'Clean Energy for All Europeans' package. The trilogue between the Council, the European Commission and Parliament began in early 2018 and should be concluded by the end of June.
2.	Revised EU Renewable Energy Directive (REDII)	**Goal:** The Commission's recommendation for a new directive defines the European framework for funding renewable energy sources for the period after 2020. Together with the draft Governance Regulation, it should ensure that the binding EU goal for expanding renewable energy by 2030 is achieved. **Scope:** The recommendation of the European Commission contains regulations for funding energy from renewable sources in the electricity, heating and cooling sectors as well as in transport. It also contains sustainability criteria for gaseous, liquefied and solid biofuels and bioliquids. The directive will define the first specific framework for how Member States may set up their funding for renewables in the electricity supply sector. Furthermore, the directive contains rules on partially opening funding for electricity across national borders, as well as for encouraging self-supply using renewables and citizens energy projects ('renewable energy communities'). A sector goal for the heating and cooling sector is to be agreed for the first time that will require Member States to try to increase their renewable energy share with appropriate measures. Special rules are planned to ensure that the heating and cooling networks also make a reasonable contribution. In the transport sector, marketers of fuels will be obligated to increase their renewables percentage. Among other things, by capping conventional biomass fuels there should be sufficient incentive for creating new technologies, such as innovative biofuels, electric mobility and power-to-X. **Status:** The REDII is part of the 'Clean Energy for All Europeans' package. The trilogue between the Council, the European Commission and Parliament began in early 2018 and should be concluded by the end of June.
3.	Amended Energy Efficiency Directive (EED)	**Goal:** Revision of the EED with a view to 2030, in particular the requirements relating to the EU energy efficiency goal, national energy efficiency goals and the final energy conservation obligation as well as updating other individual requirements. **Content/Facts and figures:** The European Commission and the Council have proposed an EU-wide energy efficiency goal of 30%, the European Parliament a binding goal of 35% by 2030 (compared with a projection of the European Commission from 2007). In addition, discussions revolve around obligating Member States to formulate national targets in the scope of the Energy and Climate Planning (see information on the Governance Regulation), as well as to extend Art. 7 of the EED until at least 2030, or to partially revise it. Furthermore, there are plans to revise rules on meter reading for heating and warm water. **Status:** The EED is part of the 'Clean Energy for All Europeans' package. The trilogue between the Council, the European Commission and Parliament began in early 2018 and should be concluded by the end of June.

	Instrument	State of implementation
4.	Amended EU Energy Performance of Buildings Directive (EPBD)	**Goal:** Update of the EPBD, whereby basic rules will be retained. **Scope:** The amendment contains the following benchmarks: • The rules on long-term refurbishing strategies previously contained in the EED will be integrated into the EPBD. • Another change is an obligation to instigate preparatory measures for creating an electric mobility infrastructure in the buildings sector. • Also to be implemented are rules on initial steps toward building automation as well as on a voluntary building assessment instrument, the smart readiness indicator. **Stand:** The EPBD is part of the 'Clean Energy for All Europeans' package; the amendment was adopted at first reading on 17 April 2018 by the European Parliament and on 14 May 2018 by the Council.
5.	Speeding-up the Conversion of Buildings to Clean Energy	**Goal:** This strategy should help identify potential for sustainable energy in buildings, and remove hurdles to more investment in this area. **Scope:** To exploit the potential for sustainable energy in buildings, numerous social, financial and technical hurdles must be overcome and administrative challenges dealt with. For example, consumers should be able to choose energy-efficient solutions in renovating their apartments and houses. A sufficient legal framework is necessary, and especially financing is an important aspect. To this end, a new measure, 'Smart Finance for Smart Buildings' in close cooperation with the European Investment Bank should mobilise additional public and private funding for energy efficiency and renewables. **Status:** The Initiative is part of the 'Clean Energy for All Europeans' package; negotiations are expected to be concluded in the course of 2018. **Facts and figures:** €10 billion for 'Smart Finance for Smart Buildings' up to 2020
6.	Revising the EU energy label	**Goal:** Energy labels should be designed to be more consumer-friendly and allow the customer to make a sound decision. **Scope:** The previous energy efficiency scale for household appliances, with categories from A+ to A+++, had become confusing and will be replaced with a simpler scale with categories from A to G. In addition, an EU-wide product database will be introduced that will show consumers the appliance with the greatest energy savings. **Status:** The framework regulation for this new scale entered into force on 1 August 2017; the rules will now be implemented for individual products, starting with washing machines, refrigerators, dishwashers, televisions and monitors, and lighting. The new energy labels will be visible in stores as of the end of 2019 or early 2020.
7.	Risk Preparedness Regulation	**Goal:** This regulation provides a framework for prevention and management of electricity crisis situations and obligates Member States to cooperate in a spirit of solidarity. **Scope:** The recommended regulation requires the European Network of Transmission System Operators for Electricity (ENTSO-E) and the competent national agencies to develop relevant scenarios for electricity crises in various regions or EU Member States. Furthermore, national authorities must prepare risk plans containing measure for preventing and managing electricity crisis situations. Cross-border measures must be agreed between Member States and measures not conforming to the Market are only allowed in exceptional circumstances. If an electricity crisis looms in a Member State, this State must warn the European Commission and affected Member States beforehand. Member States should work towards solving the crisis and support each other in their efforts. **Status:** The Council resolved its position in December 2017. The trilogue between the European Council, the Commission and Parliament has begun.
8.	Act amending the Gas Supply Security Regulation	**Goal:** Increase gas supply security in the EU **Scope:** The Gas Supply Security Regulation (EU) 2017/1938 provides for joint, regionally coordinated measures of EU Member States to secure gas supply. This includes risk assessments and prevention and emergency plans, a solidarity principle for drastic gas shortages, as well as the obligation for natural gas companies to present gas supply contracts and any amendments to them to the European Commission and to the Member States. **Status:** the Gas Supply Security Regulation entered into force on 25 October 2017.
9.	Cross-border grid expansion	**Goal:** Push ahead with the expansion of cross-border interconnectors to create the physical conditions for a functioning internal electricity market, simplify the integration of renewable energy and strengthen security of supply. Additional grid expansion projects must be implemented and ongoing projects completed to also reach the European 10% interconnection target in 2020 and further development toward the 2030 target year. **Scope:** Legislation has been passed for ten interconnector projects to further expand numerous interconnection points with our neighbours. An additional five interconnector projects were included in the grid development plan at the end of 2017. **Status:** The majority of legislated projects are in the approval phase or under construction, with scheduled ramp-up by 2025. Specific planning and approval of the new grid development plan projects is not expected until they are approved under the Federal Requirements Plan Act. **Facts and figures:** If all of the planned interconnectors are put into operation, over 1,000 km of lines would be reinforced or newly constructed, and the cross-border interconnector capacity would by increased by over 10 GW by 2030.

	Instrument	State of implementation
10.	Commission Communication on protecting Europe's cross-border energy and transport infrastructure	**Goal:** Among other things, protecting electricity, gas, oil and nuclear energy infrastructures from threats from terrorist attacks, for example, or natural disasters. **Scope:** The Communication contains criteria for identify identifying critical infrastructures. After this analysis, Member States should conduct risk assessments and together with the Commission, determine what protection measures should be taken. **Status:** The Communication was submitted in September 2017; work will begin as soon as the Framework Directive of the European Programme for Critical Infrastructure Protection (EPCIP) has been adopted.
11.	Communication of the Commission on the 15% interconnection target by 2030	**Goal/Scope:** The expansion of cross-border interconnectors is to be strengthened in order to reduce current congestion and thereby also create the physical framework for a functioning internal electricity market, simplify the integration of renewable energy and strengthen security of supply. The European Council underlined the importance of cross-border interconnector capacity for the internal electricity market in October 2014 and confirmed the 15% interconnection target for 2030 which had been proposed the European Commission. **Status:** The European Commission presented recommendations made on the basis of an expert commission report regarding how to operationalize an increase of the interconnection target to 15% by 2030. Three threshold levels were established as indicators for the urgency of taking action. **Facts and figures:** • €2/Mwh price difference between two bidding zones • 30% thermal transmission capacity/renewables generating capacity • 30% thermal transmission capacity/peak load
12.	Regional partnerships	**Goal:** Regional partnerships can enable Member States to contribute to the implementation of European regulations, to test new policy measures before they become European law, and to consult with neighbouring countries on a regular basis regarding new developments. Regional partnerships thus support mutual consensus for national challenges and lead to further integration of European electricity markets. **Scope:** Electricity neighbour networks most recently focused on creating a basic consensus on make electricity markets more flexible. The Pentalateral Energy Forum is currently working on strengthening coupling of regional electricity markets, creating regional supply security reports and on better cooperation in preventing crises. The North Sea cooperation was formalized in the energy area in 2016, and includes the topics of maritime spatial planning, network development and co-ordination, sponsoring and financial support for offshore wind energy and creating standards for offshore wind energy generation. The Baltic Energy Market Interconnection Plan (BEMIP) encourages coupling of regional electricity markets as well as regional aspects of supply security. The North Sea cooperation conducts abstract and practical studies on hybrid infrastructure that can be used both for trading and for transmitting offshore wind power.
13.	Revised Cross-Border Renewable Energy Ordinance (GEEV)	**Goal:** Open up some of the auctions under the Renewable Energy Sources Act to bidders from other Member States. **Scope:** Bidding for renewable energy resources will be opened up for 5% of annual capacity to be installed to include installations in other EU Member States; this applies both to PV and onshore wind generators. These cross-border bid invitations will accompany national bids. **Status:** The new Ordinance was adopted by the German government in June 2017, and extends its previous application of use of PV installations to include onshore wind-powered installations. **Status/Facts and figures:** In the fourth quarter of 2016, a pilot cooperation project was successfully conducted, in which Germany and Denmark reciprocally opened their bid invitations for ground-mounted solar PV systems. The Federal Government is conducting negotiations with other Member States on conducting additional open bid invitations.
14.	Energy congestion management on the Austria-German border	**Target:** less network load in Germany, Poland and the Czech Republic, more energy supply security and savings for grid operators **Scope:** Electricity trading between Germany and Austria has reached a level that exceeds the ability of grids to transport this energy. Both countries therefore agreed on introducing congestion management starting in October 2018. Energy trading will be limited, yet at least 4.9 gigawatt should be available for trading. **Status:** Electricity congestion management will enter into force in October 2018. **Facts and figures:** German electricity customers will save several hundreds of millions of euro annually.
15.	Regulation on the internal electricity market in the EU	**Goal:** Further develop and strengthen the internal electricity market **Content:** (according to the general approach taken by the Council): The electricity market regulation contains a number of rules on how to set up and develop the European retail electricity market. This includes ground rules for retail electricity and balancing energy markets that should simplify cross-border electricity trade and make market access easier for various flexibility options. Furthermore, Member States will be able to decide themselves how to solve their network congestion problems. They can either restructure their bidding zones or solve network congestion problems by expanding the grid, optimising existing networks and redispatching. Member States are required to submit a catalogue of measures. Furthermore, the regulation includes rules for creating capacity mechanisms that are to be temporary, market-driven and technology neutral, including requirements for heavy CO_2-emitting power stations. Other requirements apply to structure and tasks of European associations of transmission and distribution system operators, as well as a legal framework for Network Codes and Guidelines. **Status:** The regulation is part of the 'Clean Energy for All Europeans' package. The Council of Ministers resolved a general policy at the Energy Council in December 2017. The European Parliament adopted its final position in the first quarter of 2018. The trilogue between the European Council, the Commission and Parliament has begun.

	Instrument	State of implementation
16.	Directive on the internal electricity market in the EU	**Goal:** Expanding flexibility, competitiveness and fair pricing in the electricity market; consumers are the focal point of the energy transition. **Content:** (according to the general approach taken by the Council): The electricity market directive strengthens consumer rights. Consumers should now be able to more easily adjust and monitor their energy consumption, e.g. using dynamic electricity price agreements that reflect prices on the electricity exchange, or using intelligent metering systems – smart meters – that provide consumers transparent overviews of their electricity consumption. Consumers may participate in electricity markets as active customers or may join an energy community. Aggregators will also help make markets more flexible. In addition, there are rules that enable transmission and distribution system operator to own and operate battery-storage system under strict conditions, if they commit to investments by 2024. **Status:** The Directive is part of the 'Clean Energy for All Europeans' package. The Council of Ministers resolved a general policy at the Energy Council in December 2017. The European Parliament adopted its final position in the first quarter of 2018. The trilogue between the European Council, the Commission and Parliament has begun.
17.	ACER Regulation	**Goal:** Adapting ACER (Agency for the Cooperation of Energy Regulators) to the new electricity market design **Scope:** The Commission's recommendation provides for adapting voting rules in the Board of Regulators (from a two-thirds majority decision to simple majority) and simplifying the voting on new methods. ACER contains additional competencies, for example for approving a method for European monitoring of supply security. In addition, the role of working groups in ACER will be formalized and strengthened within the organisation. **Status:** The regulation is part of the 'Clean Energy for All Europeans' package. A general approach was agreed on in June 2018 which will provide the basis for future trilogue negotiations between the European Council, the Commission and the Parliament.
18.	Regulation on determining a guideline for system equilibration in the electricity system	**Goal:** This regulation aims to ensure harmonisation of European procurement and provision of balancing energy. It should provide more efficiency in system equilibration and balancing energy markets, allow for cross-border exchange of balancing energy and open up the market for system balancing energy to all potential providers. **Scope:** The regulation contains technical, operational and market-related provisions that affect the functionality of balancing markets in the EU. This includes procurement of balancing energy, activating balancing energy and billing for market participants. The regulation also requires the transmission system operators to develop harmonised methods for transmission capacity for cross-border exchange of balancing capacity reserves. **Status:** The regulation entered into force November 2017.
19.	Directive to amend Directive 2009/73/EC concerning common rules for the internal market in natural gas	**Goal:** Uniform legal framework for pipelines from and to non-member countries for creating an integrated gas market in the EU **Scope:** The scope of the gas directive and the gas regulation will be expanded to include pipelines from and to non-member countries; this affects provisions on non-member access, deregulation and ownership unbundling and transparency. **Status:** Recommendation of the European Commission of 13 November 2017; a quick consensus is improbable, due to legal concerns of various Member States (including Germany).
20.	Tallinn e-Energy Declaration	**Goal:** Strengthening digital solutions in the energy sector **Scope:** The non-binding declaration suggests various ways to develop a European digital energy strategy, including forums and stakeholder working groups, regional pilot projects for test runs of innovative digital energy systems, more use of national and EU funding for digital innovations in the energy area. How the overall strategy will be coordinated and financed is as yet still unresolved. **Status:** Signed by the Commission and the Member States in September 2017
21.	Energy Diplomacy Action Plan	**Goal:** Strengthening external dimension of the Energy Union with a coherent EU foreign policy for energy **Scope:** This action plan specifies four priorities: diversification of sources, suppliers and routes; expanding energy partnerships and dialogues; continual improvement of nuclear safety; and defining international energy architecture and multilateral initiatives. **Status/Facts and figures:** The action plan was resolved in July 2015, and will be in effect for an undetermined period. Since then, energy has become an important component of cooperation between the EU and neighbouring countries. Plans provide for improved information exchange between the EU and neighbouring countries, to encourage transfer of knowledge and technology. In recent years, the link to climate diplomacy was reinforced.
22.	Market stability reserve in the EU emissions trading system	**Goal:** Reduce the surplus of ETS allowances **Scope:** As soon as the supply of allowances exceeds 833 million, the amount available for auction will be reduced, and if the supply falls below 400 million, it will be increased. The amount available for auction is changed by moving allowances into the reserve or releasing them from the reserve. Any surplus from shut-down of electricity generation capacities are better absorbed by the market stability reserve, and additionally, Member States can in this case voluntarily delete emission allowances from the national auction amounts. As of 2023, allowances will be irreversibly removed from the market stability reserve if they exceed a certain minimum amount. **Status:** The market stability reserve will start operation in 2019. **Facts and figures:** The ETS reform for the fourth trading period also stipulates that the amount of emission allowances that the market stability reserve absorbs should be 24% (instead of currently 12%).

	Instrument	State of implementation
23.	Reform of the emissions trading system for the period 2021–2030	**Goal:** The price signals of the ETS should be strengthened and at the same time the industrial competitiveness of energy-intensive industry maintained. **Scope:** The total number of emission allowances will be lowered annually by 2.2%, starting in 2021, so that by 2030 emissions in the ETS sectors will sink by 43% compared with 2005. It is no longer possible to use allowances from international project mechanisms. In addition, rules for distribution of free allowances to certain polluters will be still be in place, if they are faced both with high emissions and strong international competition. The list of sectors subject to possible carbon leakage is compiled on the basis of trade and emission intensities. Furthermore, various funds will be set up for modernising energy systems and promoting innovate technologies for climate protection. **Facts and figures:** The reform will lead to a reduction of around 484 million tonnes of CO_2 equivalent between 2021 and 2023 – this is equivalent to more than half of the total annual greenhouse gases produced by Germany. **Status:** Entered into force April 2018
24.	Moving allowances that were held back into the market stability reserve	**Goal:** Retain the functionality of the ETS in the face of high surpluses in emission allowances and price erosion **Content/Status/Facts and figures:** Retention of 900 million allowances between 2014 and 2016 that should have been auctioned in the period 2019-2020 (backloading). These allowances should be deposited directly to the market stability reserve.
25.	Linking the EU emissions trading system with the Swiss emissions trading system	**Goal:** First step toward the long-term goal of an international emissions trading market **Scope:** The link should harmonize the market conditions for European and Swiss companies by means of allowance prices that align. **Status:** The agreement on linking both systems was signed in November 2017. Ratification by the EU and Swiss Parliament is still pending.
26.	Effort Sharing Regulation	**Goal:** Setting binding national emission targets in the non-ETS sectors for the EU Member States by 2013 **Scope:** National goals range between 0% and 40% of GHG reductions compared with 2005, depending on GDP per capita in the respective Member State. However, flexible mechanisms are allowed for reaching the targets. **Status:** The new effort sharing regulation entered into force in the summer of 2018. **Facts and figures:** Germany has a reduction target of 38% over 2005.
27.	Strategy for low-emission mobility	**Goal:** Reducing CO_2 emission in transport **Scope:** The European Commission presents new initiatives for low-emission mobility in this strategy. The strategy is one of the instruments for modernising the European economy and strengthening the internal market. It covers the following areas in particular: more efficiency in the transport system by using digital technologies, smart pricing and continued support for the use of low-emission means of transport; more rapid introduction of low-polluting alternative sources of energy in the transport sectors, e.g. with innovative biofuels, electricity and synthetic fuels from renewable energy sources; removing hurdles to electrification of transport; migration to zero-emission vehicles. Furthermore, this strategy should strengthen European efforts to reduce emissions in international air and shipping transport. **Status:** This strategy was published in July 2016.
28.	'Europe on the Move' mobility package	**Goal:** Create street and mobility systems for the future that enhance competitiveness and social justice and provide a clear path for achieving zero emissions **Scope:** 'Europe on the Move' comprises: ● a policy statement outlining a long-term plan for clean, equitable and competitive mobility ● eight initiatives especially aimed at improving the functionality of the road haulage market and employment conditions and social protection of employees and introducing a smart system for collecting road usage fees in Europe ● a number of non-legislative accompanying documents with flanking measures that will accelerate the transition to a sustainable, digital and integrated mobility system (investment financing for infrastructure, research and innovation, collaborative platforms, etc.) **Status:** The package was published in May 2017.
29.	Second mobility package for regulating CO_2 emissions of passenger cars and light commercial vehicles	**Goal:** Reducing CO_2 emissions in transport **Scope:** CO_2 emissions of new fleets of passenger cars and light commercial vehicles should be reduced from 2021 to 2025 by 15%, and by 2030, by 30%. In addition, 30% of new automobile models should be equipped with electric or alternative drives, where possible; manufacturers should be rewarded with a bonus point system. On the other hand, the package does not provide for a binding minimum percentage of electric cars. **Status:** This measure is part of the second mobility package published by the Commission in November 2017. **Facts and figures:** If car makers do not fulfil the CO_2 reduction target in their new fleets, they will be required to pay a €95 fine for each additional gram of CO_2 emitted. In addition, the Commission aims to set aside €800 million of additional funds for expanding the network of electric vehicle charging points.

	Instrument	State of implementation
30.	G20 Action Plan on Climate and Energy for Growth	**Goal:** The G20 countries, with the exception of the USA, have expressed in the Action Plan their commitment to the unqualified implementation of the Paris Agreement and to efficient transformation of the energy systems in accordance with climate policy goals of the Paris Accord. Increased energy efficiency and use of renewables as well as aligning financing efforts with the goals of the Paris Accord with investments in low-carbon technologies and future-oriented infrastructure play a major role. **Scope:** In the Plan, the G20 countries agreed to more cooperation in implementing national contributions (NDCs), developing long-term climate protection strategies and aligning global financing with the Paris Agreement. They emphasize the importance of creating a proper investment framework and commit to stronger cooperation and exchange of successful examples of energy efficiency and renewable energy, to improving access to energy and removing inefficient subsidies for fossil fuels. An optional monitoring process was also suggested, for supervising progress of the energy transition. The Action Plan was resolved at the G20 Summit in Hamburg on 7-8 July 2017, by 19 of 20 countries (excluding the USA) as an annex to the joint closing statement.
31.	23rd World Climate Conference (COP 23)	**Goal/Scope:** Preparations for implementation of technical regulations of the Paris Climate Agreement; this includes transparency rules for the NDCs, setting up the Talanoa dialogue as a test run for the first global inventory in 2023, new NDCs for 2020, and new rules for the market mechanisms. **Status:** The Conference took place in November 2017 und the presidency of Fiji.
32.	IEA/IRENA Study: 'Perspectives for the Energy Transition – Investment Needs for a Low-Carbon Energy System' carried out under the auspices of the German G20 presidency	**Goal:** This study commissioned by the BMWi provides an initial look into the effects of implementation of the Paris Agreement on the energy sector It should provide impetus for future investment plans. **Content/Facts and figures:** The study shows that extensive decarbonisation of the energy system by 2050 is ambitious, yet technically possible and economically feasible. The additional investments necessary up to 2050 amount to 0.3% of global GDP. Investments in energy efficiency of all sectors will have to increase by a factor of 10 compared with the current level. Investments in energy generation would not increase significantly, but much of the funding would have to be diverted, especially to renewables. The study also found that this type of modern energy supply will provide impetus for innovation, sustained economic growth and skilled employment. **Status:** This study was published in March 2017.
33.	Bilateral energy partnership with Mexico	**Goal:** Full-scale bilateral exchange with Mexico regarding energy policy **Scope:** The work programme for the first year comprises these topics: liberalization of the electricity market, energy efficiency in industry, integration of large amounts of fluctuating renewable energies and transparency in the area of crude oil and gas (EITI). **Status:** The German-Mexican energy partnership was founded in 2016. Numerous implementation measures were initiated in the first 12 months of its existence, and successfully concluded.
34.	Bilateral partnership with Australia	**Goal/Scope:** Exchange of information on challenges and opportunities, especially regarding: • market design and cost-effective integration of renewable energy resources in the electricity supply sector • long-term energy planning, including emission reduction • energy efficiency in industry • storage technologies • climate change mitigation measures in island developing countries **Status:** After a preparatory meeting in Hamburg in May 2017 the first meeting of the Energy and Resources bilateral working group took place in November 2017 in Perth.
35.	Bilateral energy partnership with the United Arab Emirates	**Goal/Scope:** Cooperation and information exchange, especially in the areas of renewable energy resources, energy efficiency, market design and sustainable transport **Status:** Up to now, two high-level steering group meetings in January 2017 and January 2018. In addition, there have been several bilateral expert workshops as well as study trips of Emirates delegations to German, on key issues of the energy partnership, most recently in April 2018 on the topic 'Electricity markets and network integration for renewable energies'.
36.	Berlin Energy Transition Dialogue	**Goal:** This conference provides a forum for international decision makers in energy and foreign policy, for industry, the scientific community and the general public, in order to discuss current developments in energy policy, innovative policy mechanisms, new investment opportunities and business models in connection with the global energy transition. **Scope:** Participants exchange knowledge on market design, energy efficiency, security of supply, structural change and investment payments. **Status:** the fourth international energy transition conference took place on 17-18 April 2018. **Facts and figures:** more Than 2,000 energy experts from around 100 countries took part, including 30 energy ministers or deputy ministers.
37.	Energy Export Initiative	**Goal:** The Federal Government specifically supports German businesses in tapping into foreign markets and expanding exports of German renewable energy and energy efficiency technologies. To this end, the Renewable Energy Export Initiative and the Energy Efficiency Export Initiative were merged into a single 'Energy Export Initiative'. **Scope:** The focus is on technical solutions in the field of renewable energy, energy efficiency, storage technologies and smart grids. Please see the following link for more details: www.german-energy-solutions.de. **Status/Facts and figures:** Annually there are around 160 events in this initiative.

	Instrument	State of implementation
38.	Travelling exhibition: "Energiewende – Germany's Energy Transition"	**Goal:** The goal of this exhibition is to clear up misunderstandings that frequently arise regarding the German energy transition, to provide information on the basic elements of the transition and to advertise for better international networking for sustainable energy policy. The target audience of the exhibition is the general, interested and international public. **Scope:** The development of German energy policy since the 1970s is illustrated in uncomplicated terms at 19 interactive stations. The exhibition is available in six languages: twice in English, and one each in German, Spanish, Mandarin Chinese and Arabic. **Status/Facts and figures:** Federal Minister Steinmeier inaugurated the exhibition in Beijing in April 2016. It has since been shown in 60 different places in 25 countries (as of early 2018).
	Chapter 4: Renewable energy	
39.	Revision of the Renewable Energy Sources Act 2017 (EEG 2017)	**Goals:** The Act aims to ensure the cost-effective continued expansion of renewables, establish a level playing field for all stakeholders in the auction system, maintain stakeholder diversity and comply with the deployment corridors for renewable energy. **Scope:** The necessary remuneration for most of electricity from renewable energy installations is determined through auctions. Better dovetailing between the expansion of renewables and grid expansion by temporarily limiting local onshore wind expansion in case of grid congestion. The remuneration for onshore and offshore wind, photovoltaics and biomass is determined through an auction system. Small installations are exempted from the obligation to take part in the auction process. **Status:** Adopted in July 2016. Entered into force January 2017. **Facts and figures:** Annual expansion targets/quantities up for auction: ● PV installations: 600 MW per year ● Onshore wind up to 2019: 2,800 MW gross per year; then 2,900 MW from 2020 onwards ● Offshore wind: 500 MW each year in 2021 and 2022; 700 MW per year from 2023–2025, and on average 840 MW per year starting in 2026 ● Biomass: 150 MW from 2017–2019 and 200 MW from 2020–2022
40.	Act to Revise the Renewable Energy Sources Act (EEG) 2017	**Goals:** A funding system designed in a way that respects state aid law, and better systematisation of the rules governing self supply. **Scope:** The rules surrounding self-supply were revised, but only certain areas of the current legal situation were modified (particularly with regard to modernised existing plants and reporting requirements). With vested rights adequately protected, existing self-supply installations will have to contribute partially to the EEG surcharge in the future if they undergo modernisation measures. The surcharge relief for new CHP installations (initial use for self-supply after 31 August 2014) will be revised and adapted to state aid rules. Reporting obligations for self-supply which were previously regulated by both the Equalisation Mechanism Ordinance and the Renewable Energy Sources Act are now harmonised in the Renewable Energy Sources Act. **Status:** Adopted in December 2016. Entered into force 1 January 2017.
41.	Revision of the Renewable Energy Sources Act (landlord-to-tenant electricity)	**Goals:** With the Landlord-to-Tenant Electricity Act, the EEG Act provided funding availability for solar power supplied by the operator of a solar PV installation installed on a residential building, or a third party without putting it on the grid, to a tenant of the same building or an adjacent building in the immediate vicinity. Furthermore, a part of the privileges for Citizens' energy companies in the scope of Wind-to-Land auctions were suspended, because they led to a distortion of competition. **Status:** Adopted in June 2017. Entered into force July 2017.
42.	2015 Revision of the Market Incentive Programme	See Chapter 5
43.	EU Directive on biofuels and indirect land use change	See Chapter 7
44.	'Renewable Energy Storage' KfW funding programme	See Chapter 6
45.	Renewable Energy Export Initiative	See Chapter 3
46.	Renewable Energies Heat Act	See Chapter 6
47.	Market Incentive Programme for renewables in the heating market	See measure monitoring Chapter 6.4
48.	Low temperature heat networks with seasonal thermal energy storage ('Model project heat networks systems 4.0')	**Goal:** Preparing for a broader market introduction of innovative heat networks systems of the fourth generation with a high share of renewable energy sources and efficiently used waste heat. **Scope:** Funding with four modules in total: Funding for feasibility studies of up to 60% of costs, for realisation of a heating network system 4.0 of up to 50%, supplemental funding for scientific cooperation (capacity building) as well as for information campaigns for potential customers for reaching a higher subscriber numbers for model projects. **Status:** Entered into force July 2017 **Facts and figures:** Market reaction greatly exceeded expectations, by early June 2018, 54 applications for feasibility studies and 3 applications for realisation of heating network systems 4.0.

	Instrument	State of implementation
	Chapter 5: Energy consumption and energy efficiency	
49.	KfW Energy efficiency improvement Programme for Production Facilities and Processes	Monitoring of central measures for funding energy savings is outlined in Chapter 5.4
50.	Energy Efficient Networks Initiative	
51.	Energy audit for non-SMEs	
52.	Programme to Promote High-efficiency Cross-cutting Technologies	
53.	Waste heat	
54.	Refinement of the SME Energy Transition and Climate Action Initiative	
55.	Programme to Promote Energy-efficient and Climate-smart Production Processes	
56.	Support for market monitoring	
57.	National Top Runner Initiative	
58.	EU Energy Label Directive	
59.	Competitive tendering scheme for electrical energy efficiency measures (STEP up!)	
60.	Energy Savings Meter pilot programme	
61.	Funding guidelines for energy management systems	
62.	'Germany Makes it Efficient' awareness-raising and mobilisation campaign	**Goal:** The 'Germany Makes it Efficient' awareness-raising and mobilisation campaign is aimed at informing all the stakeholders about the joint project that is the energy transition, and convincing them of the need for yet more efficient use of energy. **Scope:** The campaign is geared to private households, business enterprises and public institutions alike, and involves all the stakeholders in a stakeholder dialogue. **Status:** The campaign started in May 2016; consumer information is an ongoing task.
63.	Energy and Climate Action Campaign of the German Hotel and Catering Association (DEHOGA)	**Goals:** The DEHOGA Energy Campaign supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is one of the first and biggest sector campaigns for energy efficiency and climate change mitigation in Germany. It specifically aims to provide sector-specific information and advice on efficiency and cost-saving potential and how such potential can be tapped in the hospitality industry. **Scope:** A number of tools have been developed, including energy-saving fact sheets, an economic viability calculator and a "virtual" hotel in the form of a 3D animation that provides interactive information about modern building services engineering and relevant user behaviour. In addition, energy consultant alliances, energy discussion groups and energy efficiency networks provide opportunities for knowledge-sharing within the industry. **Status:** As a result of onsite energy advice, so far it has been possible to cut over 30,000 tonnes of carbon dioxide emissions each year and save €10 million in costs. This is a significant contribution to climate protection and developing sustainable high-quality tourism in Germany. The DEHOGA Energy Campaign serves as a model for the development of other sector-specific approaches. Plans are in place for DEHOGA to share its best practices and experience with other industries/ associations.
64.	Promotion of energy efficiency managers to unlock potential, e.g. in business parks	**Goal:** Sponsoring climate change mitigation in industrial and commercial centres **Scope:** Funding concepts and personnel for implementation **Status:** The 'Energy-related urban renewal KfW 432' programme facilitates funding for refurbishing managers for urban quarters, which can also comprise business parks. The Municipal Guidelines (Kommunalrichtlinie) of the Environment Ministry provide for a sub-category 'Climate change mitigation in Industry and Business Parks' and climate protection management for implementing the measures thus identified. An amendment of the guidelines aims to provide funding for municipal energy management for all type of energy consumption in a municipality and to end the sub-project 'Industry and Business Parks'. However, it should still be possible to apply for a study on the potential of using waste heat from industry and trade. The BMU is responsible for the Municipal Guidelines. **Facts and figures:** Around 200 urban quarters are currently being funded in the scope of the 'Energy-related urban renewal' programme. There is no data on how many of the urban quarters also include business parks. A total of 16 climate change mitigation projects for the category 'Industry and Business Parks' were funded between 2013 and 2016. Five more projects were started between 2017 and April 2015.

	Instrument	State of implementation
65.	Energy Efficiency Export Initiative	See Chapter 3
66.	Energy Efficiency Platform	**Goal:** Continual dialogue platform for further development of energy efficiency policy **Scope:** The Energy Efficiency Platform was founded in 2014. It assists in development of the National Action Plan on Energy Efficiency (NAPE) and is involved in its implementation. **Status:** There were two plenary meetings in 2016. Furthermore, the work of the working groups 'Innovative financing instruments', 'Legal framework/energy services', 'Advice and information', 'Competitive auction systems' and 'System issues' were continued. In addition, a special workshop was held on the connections between raw material and energy efficiency.
67.	Development of KPIs and benchmarks in the commercial sector	**Goal:** To capture current and future energy consumption and to compare both using accepted, objective benchmarks **Scope:** Support is given to R&D projects focussing on the development of comparative KPIs, standards and benchmarks for the trade, commerce and services sector, and industry. Data collection and R&D notices are planned for 2016. The project has been completed.
68.	'Development of ICT electricity needs in Germany' study	**Goal:** Measure energy consumption in the ICT area and observe its development. **Scope:** A study conducted in 2015 forecast trends in consumption and identified savings potential for the various subsectors of ICT. On the basis of this information, measures to unlock the identified potential are developed in a stakeholder process. **Status:** This study has been concluded.
69.	Federal programme of the Federal Ministry of Food and Agriculture to improve energy efficiency in the agricultural sector.	**Scope:** Advisors approved by the Federal Office for Agriculture and Food are to develop energy savings strategies for single farms.
70.	Relaunch of the Federal Programme to Promote Energy Efficiency in Agriculture and Horticulture	**Status/Scope:** Programme that ran from 2009-2012 is reintroduced for the period 2016–2018 to support SMEs in the modernisation and construction of new low-energy buildings for plant and vegetable production. By the end of June 2017, a total of 388 applications had been submitted for total funding of around €14 million.
71.	Review of the efficiency requirement in the Federal Immission Control Act	**Status/Scope:** The Federal Government is examining the extent to which the economical and efficient use of energy under the Federal Pollution Control Act can be further clarified as an operator obligation. The research project titled 'Defining energy-efficiency related operator obligations under the Federal Immission Control Act' aims to more specifically define the legal framework for operator obligations under the Immission Act and to clarify the legal scope for more specific requirements.
	Chapter 6: Buildings	
72.	CO_2-Building Modernisation Programme: residential buildings	Monitoring of central measures for funding energy conservation is outlined in Chapter 6.4.
73.	CO_2-Building Modernisation Programme: non-residential buildings	
74.	Energy Efficiency Incentive Programme (APEE), measures carried out by KfW (Reconstruction Loan Corporation) and BAFA	
75.	National Efficiency Label for old heating systems	
76.	Promotion of heating optimisation using high-efficiency pumps and hydraulic balancing	
77.	Market Incentive Programme on Promoting Measures for Use of Renewable Energy in the Heating Market (MAP)	
78.	Energy-efficient Buildings 2050 - Innovative Projects for a Virtually Climate-Neutral Building Stock in 2050	
79.	Energy consulting	

	Instrument	State of implementation
80.	Research network ENERGIEWENDEBAUEN (Building the energy transition)	**Goal:** Strengthening exchange of information at the interface between research, policy and practice. Faster transfer of results and further development of research funding. **Scope:** Information is exchanged on an online platform. In addition, there are regular events and workshops, e. g. early 2017, the 1st ENEGIEWENDBAUEN Conference with over 300 participants. The accompanying research of the research initiative serves as a motor of the network. To systematize exchange of information with the professional divisions of the BMWi, a Ministerial Counsellor was created in late 2017. **Status:** A research network was started in October 2014. Since then, over 800 members have registered. Expert recommendations from the research network formed the basis for the 'Solar Construction/Energy-efficient Cities' funding initiative (see below). At the end of 2017 the research network submitted a position paper on the consultation procedure for the 7th Energy Research Programme.
81.	'Efficiency House Plus' funding initiative	**Goal:** Continuing development of climate-friendly, affordable buildings A federal Efficiency Plus Building Standard will be established that will encourage viewing the relationship between primary and final energy demand and use of renewables in the buildings sector. **Scope:** Transfer of technology takes places by means of exemplary model projects, a network, and information and competence centre for future-oriented construction operated by the Federal Government in Berlin and on online platforms. In addition, there are regular events, workshops, appearances at trade fairs and special events regarding this sustainable building standard that will conserve energy (e.g. national and international construction trade fairs, Berliner Energietage, and the World Exposition in Astana 2017). The Efficiency House Plus initiative and its network build on the accompanying research of the Efficiency House Plus Model Project and other research topics relating to this building standard. To provide additional large-scale social impetus and an active dialogue with citizens, the government Information and Competency Centre for Future-oriented Construction was opened as part of the federal model project 'Efficiency House Plus' in Berlin. **Status:** Since 2017 over 37 federal model projects confirm that this building standard is practicable and climate-friendly. Scientific projections see a carbon-savings of 18 million tonnes per year as of 2050 given a market penetration of 15% for this building standard in new construction and remodeling. In addition, the energy surplus provided by the Efficiency House Plus houses can also make up for buildings that do not achieve climate neutrality by 2050. The Efficiency House Plus will be continued and expanded.
82.	Energy conservation law for buildings	**Goal:** The Energy Conservation Ordinance (EnEV) together with the Energy Conservation Act (EnEG) and the Renewable Energies Heat Act (EEWärmeG) provide an important contribution to energy savings in the buildings sector. While respecting the principles of economic efficiency, the existing set of regulations helps achieve federal energy policy targets, especially the goal of a practically climate-neutral building stock by 2050. **Scope:** The conservation ordinance and the act regulate the energy requirements for existing buildings and those to be constructed, including building installation technology and energy certificates. The heat act regulates the obligation to use renewables in buildings.
83.	Energy Transition Platform for Buildings	**Goal:** Continual dialogue platform for further development of energy efficiency policy **Scope:** The Energy Transition for Buildings Platform was founded in 2014. Given the ambitious goals in the building sector, the potential, challenges and measures are discussed with stakeholders from the property sector, business, industry, consumer representatives and the public sector in both the plenary session and in working groups. The 7th meeting of the platform took place in late 2017.
84.	Customised renovation roadmaps for buildings	**Goal:** Standardised recommendations for tailor-made, gradual energy retrofits **Scope:** The customised renovation roadmaps provide building owners a clear overview for a phased renovation of their buildings. Besides strictly energy-related aspects, the roadmap also focuses on the specific options for the building owner and the specific condition of the building when identifying the renovation approach. The programme was launched in May 2017 and integrated into energy consultation for residential buildings.
85.	Heat Networks 4.0	**Goal:** Sponsoring by means of basic funding supplemented by performance-related scaled bonuses is provided for climate-friendly and especially cheap network heating with high shares of renewables and waste heat use. **Scope:** Model projects for innovative climate-friendly heat supply for urban quarters and districts using networks of the 4th generation. These demonstrate low temperature levels, renewable shares of between 50% and 100% and usually have large seasonal heating storage. **Status/Facts and figures:** The Programme was initiated on 1 July 2017. Funding is provided for feasibility studies and construction as well as information campaigns and scientific accompaniment of model projects.

	Instrument	State of implementation
	Chapter 7: Transport	
86.	Continued development of the 2013 Mobility and Fuels Strategy	**Goal:** The Mobility and Fuels Strategy adopted by the Federal Cabinet in 2013 is continued as an important vehicle for implementing the energy transition in the transport sector as defined in the National Sustainability Strategy. It currently provides an overview of technologies as well as energy and fuel options for the various modes of transport. **Scope:** As a 'learning strategy' the Mobility and Fuels Strategy shows how the energy transition in the transport sector can be implemented in the long term. A central issue in this context is to identify where it is possible to gradually replace the combustion engine with an electric motor, given that (i) the energy efficiency of an electric motor is at least twice that of a combustion engine and (ii) renewable energy can be integrated far more easily into electric motors than into combustion engines. To reach the goals of the Federal Government's Energy Concept, overland transport should be electrified to the greatest extent possible on a step-by-step basis. The keys to achieving this are the promotion of electric mobility with battery and fuel cells and the redoubling of efforts to move traffic to rail.
87.	Clean Air 2017–2020 immediate action programme	**Goal:** Finance implementation of measures in municipalities where nitrogen dioxide thresholds are exceeded. Nitrogen dioxide immissions should be greatly reduced and the thresholds observed very soon, however at the latest by 2020. **Scope:** The focus is on electrification of urban vehicle parks (especially taxis and public buses), including expansion of charging infrastructure and measures on stabilising the power networks, upgrading in the transport sector diesel buses to low-emission motors, improved traffic management and digitalization of municipal traffic routing. Additional measures include a purchase premium for electric vehicles, improvement of logistics strategies and encouraging bicycle traffic. **Status:** Adopted November 2017
88.	New procedure for the type approval and market monitoring of vehicles	**Goal:** By introducing a new framework for type approval, the aim is to strengthen independent tests, market monitoring and the implementation of requirements in Europe. The goal is to have an EU regulation to harmonise and tighten the approval procedure and market monitoring of motor vehicles and their trailers as well as other vehicle components.
89.	New World Harmonised Light Vehicle Test Procedure (WLTP)	**Goal:** Make available more representative and reproducible values for CO_2 emissions and fuel consumption so that the vehicle fuel consumption rates in the test scenario once again correlate more with the on-road values that the vehicle driver experiences **Scope:** The emission standards and consumption standards for passenger cars and light commercial vehicles are defined for the post-2020 period on the basis of this new procedure, wherein the stricter requirements of this procedure must be taken into account. Once the relevant EU Directive is amended, the new test cycle will also be incorporated into the passenger car energy consumption labelling system (car label) and increase the credibility and thereby the effectiveness of the label.
90.	Reform of the EU regulations on reducing CO_2 emissions of new passenger vehicles and light commercial vehicles	**Goal:** New CO_2 fleet targets for the post-2020 period A recommendation for an amendment of the EU Regulation on CO_2 Emissions for Passenger Cars and Light Commercial Vehicles was presented by the Commission and is currently in negotiation.
91.	EU Regulation to reduce CO_2 emissions of heavy-duty vehicles (HDV)	**Goal:** For the first time, CO_2 targets for heavy-duty vehicle fleets **Status:** The Commission presented a recommendation in May 2018 that is currently in negotiation.
92.	Strategy for Automated and Connected Driving – Remain a lead provider, become a lead market, introduce regular operations	**Goal:** Create the framework and necessary conditions for the introduction of automated and connected driving systems in conjunction with smart transport systems **Scope:** Implement measures in the areas of infrastructure, law, innovation, interconnectivity, cyber security and data protection, and promote social dialog to unlock the potential offered by the technologies – namely greater traffic safety, increased traffic efficiency, lower mobility-related emissions and the strengthening of Germany's position as a business and innovation hub.
93.	Passenger car label	**Goal:** The aim is to reduce the fuel consumption and emissions of passenger cars. **Scope:** Since 2011, new cars have had a passenger car label that indicates the energy efficiency of the vehicle, with green standing for energy-efficient. In addition, it also provides clear information on the fuel consumption, fuel costs and CO_2 emissions of the vehicle.
94.	Programmes to promote energy-efficient light vehicles	**Goal:** The aim is to support the market roll-out and market penetration of energy-efficient and/or low-CO_2 light vehicles with a fixed-term funding programme. **Scope:** Promoting the purchase of trucks and tractor units with compressed natural gas –CNG), liquefied natural gas (LNG), and certain electric drivetrains (battery electric vehicles and fuel cell powered vehicles) that are designed for road haulage services and whose permitted total weight is at least 7.5 tonnes. **Status:** The programme started in June 2018 and runs until 31 December 2020. A total of €10 million will be available annually.

	Instrument	State of implementation
95.	Electric Mobility Market Incentive Package	**Goal:** Force the pace on the expansion of electric mobility and the charging infrastructure **Scope:** A premium of €4,000 is paid for purchases of new all-electric vehicles and of €3,000 for plug-in hybrids. **Status:** Adopted in May 2016. Car buyers have been able to submit their applications to the Federal Office for Economic Affairs and Export Control since July 2016. Number of applications in September 2016: roughly 3000. To ensure that electric vehicles can also be used for longer distances, work has commenced on installing fast charging stations at the roughly 430 service stations on the federal motorways since autumn 2016. **Facts and figures:** To speed up the development of a market for electric vehicles, corresponding funding will be increased by a total of €1.6 billion (together with the €600 million in funds provided by the business community). Total funding is set at €1.2 billion, the costs of which are shared equally between the Federal Government and the automotive industry. The Federal Government is making €300 million available to improve the vehicle charging infrastructure.
96.	'Local Electric Mobility' funding programme	**Goal:** Support the market uptake of electric vehicles by supporting EV procurement in a municipal context and associated measures to develop charging infrastructures. Promotion of strategic research and demonstration projects in the local public passenger transport system and with electric delivery vehicles or light-duty vehicles. **Scope/Status:** The funding guidelines came into force in 2015, and were slightly updated in 2017. Seven calls for applications have been conducted up to now, one of them on execution of the Clean Air 2017-2020 immediate action programme. **Facts and figures:** Approximately €140 million are available for the period 2017-2020. In addition, funding for purchasing vehicles under the programme will be augmented with €175 million. Procurement of around 2,300 e-vehicles including the requisite charging infrastructure was funded by the end of 2017. In addition, approx. 130 e-mobility projects and several R&D projects were sponsored.
97.	Act Granting Privileges to Users of Electrically Powered Vehicles (Electric Mobility Act) and new regulations based on the act	**Goal/Scope:** The Electric Mobility Act and the new regulations based thereon – the 50th Ordinance to amend road traffic regulations and accompanying administrative provisions - give cities, towns and municipalities the legal framework to grant privileged status to electric cars. Local incentive measures can include the provision of free parking spaces or the exemption of electric vehicles from access restrictions. The opening of bus lanes or special lanes to electric vehicles is also a possibility. By making an exception in driving licence legislation for electric-drive category N2 vehicles, battery-powered vehicles with a maximum total weight of up to 4.25 tonnes can be driven with a Class B driver's licence (passenger car licence).
98.	2011 Government Programme on Electric Mobility	**Goal:** The aim is to support the market uptake of electric-drive vehicles. Many measures from this programme have already been implemented.
99.	Electric Mobility Procurement Initiative	**Goal/Scope/Facts and figures:** The share of all new vehicle purchases or hires with a vehicle emissions rating of less than 50g (alternatively: minimum electrical range of 40 km) is to be increased beyond the already agreed share of 10% to at least 20% in the future.
100.	Tax regulations concerning the use of electric vehicles for private purposes	**Goal/Scope:** The Act on Tax Incentives to Promote Electric Mobility in Road Transport of 7 November 2016 was announced in the Federal Law Gazette on 16 November 2016 and entered into force on 17 November 2016. Under the Income Tax Act, employees who charge an electric or hybrid electric vehicle at their employer's place of business or at an affiliated business and who use in-company charging facilities temporarily for private purposes can treat this as a tax-free benefit in their income tax returns (Section 3, number 46 of the Income Tax Act). Employers can also apply a 25% flat income tax rate for non-cash benefits deriving from the free or reduced-rate provision of charging facilities and for grants towards employee expenses for the purchase and use of a charging facility (Section 40 (2), sentence 1, number 6 of the Income Tax Act). **Status:** The new regulations apply from 1 January 2017 through to 31 December 2020.
101.	National Innovation Programme for Hydrogen and Fuel Cell Technology	**Goal:** The programme is to be continued from 2016 - 2026 within the framework of a follow-up programme. Funding of €161 million were made available for this purpose in the 2015 supplementary budget (2016: €25 million, 2017: €50 million, 2018: €86 million). **Scope/Status/Facts and figures:** In September 2016 funding guidelines for R&D was published, and in February 2017, funding guidelines for market activation as part of the National Hydrogen and Fuel Cell Technology Innovation Programme. Five calls for applications have been made under the market activation funding guidelines. By March 2018, 182 project applications with a volume of around €91 million were approved. Of these, 156 are research projects and studies. Of the remaining approved applications for procurement, 51 fuel cell powered buses were approved, 235 fuel cell powered passenger cars and the requisite refuelling infrastructure.

	Instrument	State of implementation
102.	'Renewable and Mobile' funding programme	**Goal:** Funding for research projects on the topic of electric mobility for the purpose of increasing its potential for climate, environmental and resource conservation, as well as contributing to an increase in the quality of life and sustainable urban development **Scope:** The Federal Ministry for the Environment provides funding to companies and institutes conducting substantial R&D projects for electric mobility. The funding project initiated in the second stimulus package was successful, and has been continued since 2012 in the Renewable and Mobile programme, including vehicle and drive designs and coupling e-vehicles with energy supply systems. **Status:** On 15 December 2017 the 4th funding announcement for this program was published, this time as a joint initiative of the BMWi and the Federal Ministry for the Environment. In addition, through the Renewable and Mobile programme, the Environment Ministry also participates in implementation of the Clean Air immediate action programme, by sponsoring purchases of electrically operated light commercial vehicles and/or passenger vehicles for taxi operation, as rental cars and for car sharing in urban transport. **Facts and figures:** The Renewable and Mobile programme has funded more than 70 projects in Germany since 2012, with more than 120 project partners and a funding volume of over €230 million.
103.	Electric Mobility Funding Guidelines	**Goals:** The aim is to promote application R&D measures and the procurement of electric vehicles (drives, value chain optimisation, information and communication technology) across all modes of transport.
104.	Motor vehicle tax	**Goal/Scope/Status:** The Act to Modify Transport Taxes of December 2012 expanded the previous motor vehicle tax exemption – limited to all-electric passenger cars – to include all-electric vehicles of all vehicle categories. In addition, tax exemption for these vehicles, if registered for the first time between 18 May 2011 and 31 December 2015, was extended from five to ten years. A five-year tax exemption was provided for such vehicles registered for the first time between 1 January 2016 and 31 December 2020. This tax exemption period was extended to a uniform 10 years for all all-electric vehicles with first registration between 18 May 2011 and 30 December 2020, with the Act to Promote Electric Mobility in Road Traffic through Tax Incentives of November 2016. Passenger cars re-engineered to all-electric drivetrains also receive preferential treatment if conversion takes place between 18 May 2016 and 31 December 2020 (see No. 99).
105.	Round Table on Gas-based Mobility	**Goal:** Organise dialog between the various market players and work with the Federal Ministry for Economic Affairs and Energy to develop a package of measures by the end of the first quarter of 2017 to reach the 4% target for natural gas mobility **Scope:** The first step was to identify a range of focus regions in Germany where the use of natural gas vehicles and infrastructure expansion could be moved forward particularly quickly. **Status/Facts and figures:** Since the programme was launched in September 2016 up to March 2017 three Round Tables have taken place, accompanied by more than 20 working group meetings. Inter alia, eight large-scale focal regions in Germany were identified where the battery of measures developed are designed to move gas-based mobility forward, both with regard to the supply of vehicles and with regard to customers and users of mobility services. Fact sheets were prepared that listed the merits of natural gas mobility in various sub-markets, in passenger car traffic as well as bus and heavy goods vehicle traffic. In an action paper, the participants listed the possibilities they perceived for advancing natural gas mobility.
106.	'Maritime Technologies of the Next Generation' R&D programme	**Goal:** Developing new technologies in the maritime sector. This should increase safety and reliability, as well as the economic viability in the shipbuilding industry. **Scope:** The four research priorities are marine engineering, manufacturing marine systems, shipping industry and marine technology. One focus is on novel production technology, organisation and connectivity. **Status:** The programme runs until December 2017. **Facts and figures:** Around €32 million will be invested annually in the form of repayable subsidies, where the beneficiary's contribution is usually around 50%.
107.	Taskforce on LNG in heavy-duty vehicles	**Goal:** Accelerate the market entry of LNG in heavy-duty freight transport **Scope:** 1. Development of measures for the development of the LNG market in Germany; 2. Assessment of the environmental and climate effects and evaluation of economic viability based on real-life values from the demonstration projects implemented by the Federal Ministry of Transport and Digital Infrastructure; 3. Creation of an information basis for feasibility and implementation aspects for users of LNG HDVs. Founded at the initiative of the Federal Ministry of Transport in November 2015.
108.	Regulations on Minimum Technical Requirements for the Safe and Interoperable Deployment and Operation of Publicly Accessible Electric Vehicle Recharging Points	**Goal/Scope:** The aim is to establish uniform standards for the EV charging infrastructure. I: Decision of October 2015 contains charger plug standards and minimum requirements for the development and operation of public-access charging points for electric vehicles. II: Aims to standardise authentication and payment at charging stations. III. Amends the existing Charging Station Ordinance to include EU requirements for intermittent charging: Operator of recharging points accessible to the public must accordingly allow any e-vehicle user to use the recharging points, even if they have no long-term electricity supply agreement. This encourages the expansion of publicly accessible charging points to fit demand with funds from the private sector, thereby assisting the market ramp-up of e-vehicles in Germany. Entered into force June 2017.

	Instrument	State of implementation
109.	2014 EU Directive on the Deployment of Alternative Fuels Infrastructure	**Goals:** Providing an appropriate minimum number of refuelling and charging points for alternative fuels and establishing necessary minimum technical standards and minimum standards for consumer information **Scope:** The implementation of the EU Directive is an integral part of the Mobility and Fuels Strategy, as the swift development of an effective refilling and charging infrastructure for alternative fuels is at the core of the energy transition in the transport sector. The National Policy Framework adopted by the Federal Cabinet was submitted to the EU Commission in November 2016. The measures of the Policy Framework will be implemented by the various ministries responsible.
110.	Funding guidelines for an 'Electric Vehicle Charging Infrastructure in Germany'	**Goal:** Development of a nationwide charging infrastructure with 15,000 charging stations across the country. Of these, 10,000 will be normal charging stations, and 5,000 will be rapid charging points. The Charging Infrastructure Funding Guidelines is part of the Electric Mobility Market Incentive Package adopted by the government on 18 May 2016. **Scope:** The funding guidelines grant a subsidy (max. 60%) for investment costs for charging points and network connection. Regular calls for applications for funding set out the terms and conditions for the respective funding phase. **Status/Facts and figures:** Entered into force in February 2017. A total of €300 million will be mobilised for the funding programme which runs from 2017 to 2020. Two calls for applications were conducted in 2017, and 3,000 applications ensued.
111.	Hydrogen infrastructure development (H_2 Mobility project)	**Goal/Scope:** Develop 400 hydrogen filling stations in Germany by 2025. The first 100 filling stations will be built irrespective of vehicle uptake (chicken and egg dilemma). **Status:** The first 50 hydrogen filling stations are part-funded by the Federal Government under the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP). Applications for funding of additional filling stations have been filed under NIP II (2016–2026). **Facts and figures:** There are currently 45 hydrogen refuelling points in operation.
112.	National Policy Framework for the deployment of alternative fuels infrastructure (NPF)	**Goal:** The National Policy Framework sets goals for publicly accessible refilling and charging infrastructures and underpins these goals with specific measures, which must be implemented by the Federal Government (in conjunction with industry where applicable) in order to reach the goals. **Scope:** The National Policy Framework adopted by the Federal Cabinet comprises the charging infrastructure for electric vehicles, the infrastructure for the supply of natural gas (CNG and LNG) and the infrastructure for the supply of hydrogen to vehicles powered by fuel cells. It forms part of the implementation of EU Directive 2014/94/EU. The National Policy Framework is a 'learning strategy' and will be reviewed regularly and adapted where necessary throughout the course of the implementation of the EU Directive. The Federal Ministry of Transport and Digital Infrastructure will set up an ongoing monitoring procedure to this end. Under the provisions of the EU Directive, a report on the state of infrastructure development must be submitted to the European Commission after three years. **Status:** The Federal Government communicated the National Policy Framework to the European Commission in November 2016.
113.	Promotion of intermodal transport through the expansion and new construction of transhipment terminals	**Goal:** The aim of efforts to promote intermodal transport is to transfer freight transport in standardised loading units from road to rail and federal waterways. **Scope:** The Federal Government promotes intermodal transport by providing grants towards the cost of constructing transhipment terminals. For Deutsche Bahn terminals, this is done through the Act on the Expansion of Federal Railways, and through a funding guideline of the Federal Ministry of Transport and Digital Infrastructure for private terminals. The funding guideline for private intermodal transhipment terminals provides support for up to 80% of eligible costs for the upgrading and construction of terminals. Following a decision by the Federal Cabinet, a spending review of the programme of financial assistance to private undertakings was conducted in 2015/2016. Within this context, it was agreed to relax rules surrounding guarantees for repayment obligations to the Federal Government. The Federal Ministry of Transport and Digital Infrastructure updated the funding guideline and submitted it to the European Commission for approval. **Status:** The new guidelines came into force in January 2017.
114.	2020 National Cycling Plan	**Goal:** The promotion of bicycle transport is a joint objective of the Federal Government, the Länder and municipalities. **Facts and figures:** Federal funding for non-investment innovative projects amounted to €3.2 million in 2016. Further to this, cycle paths also received €98 million in funding by way of federal trunk roads. An additional €1.2 million were also provided for the improvement of paths along federal waterways. Equal amounts are set out in the 2017 budget. In addition, around €1.3 billion are provided each year from the federal budget, inter alia for the improvement of municipal transport conditions, (known as 'unbundling funds'). This level of funding will continue through to 2019 and the funds can also go towards the development of the cycling infrastructure.
115.	Initiative for Digital Connectivity in Public Passenger Transport	**Goals:** At its core is a dialog and stakeholder process with representatives of the Länder, transport authorities, municipalities, transport companies and associations, industry and consumer associations. **Scope:** Involved participants and decision-makers developed a joint roadmap outlining areas where there is a need for action, as well as the necessary steps and responsibilities. The Federal Ministry of Transport and Digital Infrastructure makes a financial contribution towards the implementation of the roadmap. **Status:** The Initiative started in early 2015. The roadmap was adopted in June 2016. **Facts and figures:** A total of €16 million are available in the Future Investment Programme in the years 2016 through 2018.

	Instrument	State of implementation
116.	Federal Transport Infrastructure Plan	**Goal:** Maintenance and replacement before expansion and construction, elimination of congestion on main routes, strengthening of the more climate-friendly modes of transport **Scope:** The infrastructure expansion legislation adopted by the Bundestag forms the basis for the financing and realisation of infrastructure expansion and construction projects. **Status:** The 2030 Federal Transport Infrastructure Plan was adopted in the Cabinet in August 2016. **Facts and figures:** A total of over €270 billion are earmarked for maintenance and replacement projects and for road, rail and waterway infrastructure expansion and construction projects.
117.	Promotion of hydrogen-based mobility in rail transport as part of the NIP	**Goal/Scope/Status/Facts and figures:** The world's first-ever hydrogen-powered train was unveiled in September 2016. In the state of Lower Saxony, 14 hydrogen trains are to be introduced on non-electrified routes between 2018 and 2020, thereby replacing diesel locomotives. A total of 50 trains are to be rolled out in the passenger transport sector by 2021. In this way, the aim is to take advantage of the synergies from the development of hydrogen-based on-road mobility, particularly with regard to the production, transportation and provision of the fuel.
118.	Further development of the HGV toll/ adaptation of the European Infrastructure Costs Directive	**Goal/Scope:** The HGV toll system is to be developed further to make freight transport more climate-friendly. The aim is to scale the HGV toll depending on the energy consumption of the vehicles in a manner that is revenue neutral. This will first require an amendment to European Infrastructure Costs Directive 1999/62/EC at the EU level which defines the legal framework for Member States to levy tolls. Directive 1999/62/EC currently does not contain any provisions for a toll scale based on vehicle energy efficiency categories.
119.	Strengthening of rail freight transport	**Goal/Scope/Status/Facts and figures:** The aim is to intensify the expansion of rail transport. To this end, far higher investment in the expansion of the rail infrastructure will be facilitated between 2016 and 2018 with funds from the Future Investment Programme. Besides the implementation of projects under the requirements plan, the measures of the Second Immediate Action Programme for Seaport Hinterland Transport, which are designed to increase capacity, will be implemented starting in 2015 and through to 2020. The financing agreement for a first tranche of the Second Immediate Action Programme for Seaport Hinterland Transport has been concluded, while measures for a second tranche are currently being reviewed. Negotiations are currently underway regarding the financing arrangements for the electrification of transport routes. The measures of the Rail Freight Masterplan are to be put into effect long term, for permanent strengthening of rail freight transport: One measure sees the reduction of rail access charges in rail freight traffic with additional federal funds of €350 million annually, beginning in 2019, and if an evaluation in 2021 sees progress, funding will be extended to 2023. Rail freight transport is also strengthened through federal support for private intermodal transhipment terminals (cf. No. 112) and for private sidings.
120.	Strengthening waterways as a mode of transport	**Goal/Scope/Status/Facts and figures:** The Regulation on Contributions to Waterway Transport Enterprises for the Sustainable Modernisation of Inland Waterway Vessels of 21 July 2015 replaces the funding guideline for lower-emission engines. The federal funding guideline for private transhipment facilities also applies to facilities to transfer to waterways.
121.	Strengthening of regional economic cycles	**Goal/Scope/Status/Facts and figures:** Preparations are underway for awarding a preliminary Federal Government study on regional economic cycles. The aim of the study is to provide a preparatory analysis that will be the basis for the creation of guidelines for local authorities.
122.	Strengthening of local public passenger transport	**Goal/Scope/Status/Facts and figures:** State subsidies for local and regional passenger services (regionalisation funds) were increased to €8.2 in 2016 and this will be increased by1.8% annually in the following years. As of 2020, the Länder are to receive compensation for the discontinuation of unbundling funding within the framework of general payments from VAT tax revenue.
123.	Strengthening of cycling and pedestrian infrastructure	**Goal:** Further development of the cycling infrastructure and linking the bicycle transport system to other modes of transport via investment, non-investment and communication measures. Improvement of framework conditions. **Status:** Current invitation for projects under the National Cycling Plan for the 2016 funding year with a focus on electric mobility as well as cycling and space.
124.	Eighth Act amending the Road Traffic Act (automated driving)	**Goal:** Creating a legal basis for highly and completely automated driving **Status:** Entered into force June 2017
125.	Action plan to create ethic rules for self-driving computers	**Goal:** Creating the necessary framework for developing these new technologies as well as helping Germany retain a leading role in this process **Scope:** Action plan based on recommendations presented by the Ethics Commission for Automated and Connected Driving. **Status:** Adopted in the Cabinet in August 2017
126.	'Energy Transition in Transport funding initiative: Sector coupling by using electricity-based fuels'	**Goal:** This cross-programme research initiative will strengthen technology and policy ties between the energy, transport and maritime sector. **Scope:** The focus of the calls for funding applications is on manufacture and use of alternative, electricity-based fuels and using new technologies in mobile applications in transport and industry. **Status:** The first flagship project with broad industry participation should commence in 2018. **Facts and figures:** The BMWi has provided around €130 billion.

	Instrument	State of implementation
127.	Reduced tax rate for local public transport under the Electricity Tax Act	**Goal:** This tax break should promote use of plug-in hybrid electric vehicles and e-vehicles in local public transport. In addition to electricity tax breaks for rails and the energy tax break for fuels in local public transport, a tax break is provided for advanced technology in the form of plug-in hybrid electric vehicle and e-vehicles. **Scope:** The Electricity Tax Act was amended on 1 January 2018 to lower the tax rate to €11.42. **Status:** see above **Facts and figures:** Revenue shortfalls are estimated at €1 million annually.
128.	Continuation of reduced tax rates for natural gas and liquefied petroleum gas	**Goal:** This tax break serves as an incentive to use NO_x-free and CO_2-reduced public and private transportation in the inner cities. **Scope:** The Act to amend the Energy Tax Act of 1 January 2018 extends the tax break for natural gas up to and including 31 December 2026, with a gradual reduction in the tax rate starting 1 January 2024. Tax breaks for LP and LNG will be gradually decreased starting 1 January 2019, and by 1 January 2023 the regular tax rates should apply. **Status:** see above **Facts and figures:** Lost tax revenue for continuation of tax breaks for natural gas and liquefied petroleum gas are estimated at €1 billion for the entire term. The exact amount depends on actual fuel consumption.
	Chapter 8: Greenhouse gas emissions	
129.	2020 Climate Action Programme	**Goal:** This programme should achieve the climate goal set for 2020, i.e. reduce greenhouse gas emissions in Germany by at least 40% from 1990 levels, as quickly as possible. **Scope:** More than 110 individual measures in all sectors of the economy **Status:** Adopted in December 2014. 2017 Climate Action Report adopted by the Federal Government in June 2018, which accompanies the implementation of the measures under the 2020 Climate Action Programme. This Report presents current trends in the development of emissions in the various action areas, describes progress in the implementation of the measures contained in the Climate Action Programme and provides an outlook of the expected effect the individual measures will have on reducing emissions by 2020.
130.	2050 Climate Action Plan	**Goal:** Describes fundamental principles and orientation for delivery on the global goals set out in the Paris Agreement. It defines target corridors for emissions reduction in individual sectors by as of 2030 (sectoral targets), that will undergo a comprehensive impact assessment and then be discussed with the social partners. If necessary, adjustments can be made to the sectoral targets in 2018. **Scope:** The 2050 Climate Action Plan addresses the following action areas: energy sector, buildings, transport, industry, agriculture as well as land use and forestry. Overriding objectives and measures are also presented. The Federal Government adopted the 2050 Climate Action Plan in November 2016.
131.	Climate Action Alliance	**Goal:** Support implementation of the measures adopted under the Climate Action Programme, make it easier to realise potential that is currently rated as “not yet quantifiable” and identify additional possibilities for action **Scope:** Previous discussions on climate protection in the transport sector, in municipalities, agriculture, small and medium-sized enterprises, the craft sector and industry. The Action Alliance meets semiannually and will also assist implementing the 2050 Climate Action Plan according to a resolution of the Federal Government.
	Chapter 9: Power plants and security of supply	
132.	Electricity Market Act	**Goal:** The aim is to make the electricity market fit for the increasing share of renewable energy and to set the course for competition between flexible generation, flexible demand and storage. **Scope:** Continued development of the electricity market into an electricity market 2.0, specifically: • strengthening of existing market mechanisms • removal of barriers to access for providers of demand side management measures • more efficient grid planning • increased monitoring of security of supply • more transparency in the electricity market • introduction of a capacity reserve established separately from the electricity market • creation of a security standby reserve **Status:** At the end of 2017 three power generation units with a total capacity of around 900 MW were transferred to security standby. Five more units should follow until October 2019.
133.	Capacity Reserve Ordinance	**Goal:** Reserving 2 GW of capacity for emergency situations **Scope:** A type of strategic storage for reserves on the part of the transmission system operators. This should put them in a position to ensure electricity supply in emergencies by falling back on capacity reserves in order to provide additional electricity feed-in. **Status:** The Capacity Reserve Ordinance should be amended as soon as possible with a view to state aid clearance; after that, the first auction will take place.
134.	Amended Combined Heat and Power Act (December 2015 and 2016)	**Goal:** Contribute to reaching the climate goals, increase the flexibility of CHP plants and planning security for CHP plant operators **Scope:** Targeted support of low-carbon generation using gas-fired CHP and flexibilisation of CHP plants Commencement of audits for the 1MW to 50MW segment **Status:** Adopted in December 2016. Entered into force January 2017. **Facts and figures:** Financial support volume doubled to €1.5 billion a year.

	Instrument	State of implementation
135.	Combined Heat and Power Auction Ordinance	**Goal:** Reduce the funding costs for conventional CHP plants, open up prospects for innovative CHP systems and provide incentives for necessary investment in flexible technologies **Scope:** Mid-size CHP plants with installed power of 1MW to 50MW will only receive funding if they had previously been funded in an auction conducted by the Federal Network Agency. Innovative CHP systems also qualify for funding. **Status:** Adopted in June 2017. Entered into force in August 2017. **Facts and figures:** Annual quantities up for auction (until 2021) • CHP plants with 1–50 MW: 200 MW annually • Innovative CHP systems: 50 MW annually
136.	Act on the Redistribution of Responsibility for Nuclear Waste Management	**Goal:** Guarantee the financing of the decommissioning and dismantling of nuclear power plants and the disposal of radioactive waste **Scope:** Operators of nuclear plants will continue to be responsible for the management and reserve-backed financing of plant decommissioning and dismantling. The Federal Government will be responsible for interim and final storage in the future, the foundation 'Fund for Financing Nuclear Waste Disposal' reimburses the Federal Government costs it incurs. **Status/Facts and figures:** The Act entered into force on 16 June 2017. On 3 July 2017 German nuclear power plant operators paid a total of €24.1 billion to Bundesbank accounts of the fund. The amounts paid in comprised the mandatory basic amount of €17.930 977 226 billion and the optional risk premium of €6.216 875 476 billion.
137.	Commission for the storage of high-level radioactive waste (Final Repository Commission)	**Goal:** Develop a proposal for a fair and transparent procedure for the permanent disposal of high-level radioactive waste **Scope:** Comprising representatives from the business community, industry, environmental organisations, religious communities, trade unions, as well as non-voting members of the Bundestag and the Land governments, the Commission presented its final report on 5 July 2016. In the search for a final repository, it is in favour of a multi-stage, transparent and science-based process, which is open as to the outcome, and defines selection criteria to identify the best possible site for the final repository.
138.	Act Modernising the Repository Site Selection Act and other Legislation	**Goal:** Implementation of recommendations of the Final Repository Commission and as such, determining the site selection procedure **Scope:** Specifying the site selection procedure, starting with a blank map and ending up with the best possible final repository site
139.	Establishment of a central market master data register	**Goal:** Create a central energy industry register to simplify official and private-sector reporting, reduce the number of registers to which industry must report, and enhance data quality and transparency **Scope:** Starting in 2017, the Register will merge the master data of all the plants in grid-bound energy supply in Germany's electricity and gas market, and the master data of market stakeholders, to create a single online database. **Status:** The Core Energy Market Data Register Ordinance entered into force in July 2017. The Federal Network Agency plans to implement the Register in December 2018.
140.	Programme to promote PV battery storage units	**Goal:** Strengthen measures to serve the system and deliver more cost reduction in storage technologies **Scope:** The programme supports investment in battery storage units that are installed in connection with a PV installation and connected to the electricity grid. **Status:** Since the programme was started in March 2016, the KfW approved around 6,500 applications for assistance by the end of 2016. **Facts and figures:** Funding of €35 million for the period 2016 to 2018
141.	Amendment to the Electricity Network Access Ordinance (StromNZV)	**Goal:** Optimise the gas network access system and adapt it to the new energy sector circumstances **Scope:** Gas transmission system operators must always offer transport customers intra-day capacities as of 2018. In addition, both existing German natural gas market areas must be combined by 1 April 2022 at the latest. **Status:** Entered into force in August 2017
142.	SMARD electricity market data	**Goal:** Transparent representation of the German electricity market. **Scope:** At https://www.smard.de/en/5790, key data for the German electricity market and some for other European markets can be accessed in real time, presented in graphics and downloaded. It is possible to look up data on generation, consumption, wholesale prices, imports and exports, as well as data on balancing energy, for differing time periods and in graphic form. **Status:** The platform has been online since July 2017.
	Chapter 10: Affordable energy and a level playing field	
143.	Special compensation arrangements in the Renewable Energy Sources Act	**Goal:** The aim is to ensure that electro-intensive businesses and rail operators are not put at a disadvantage in relation to international competitors, and that jobs are therefore not lost, as a result of the promotion of renewable energy in Germany. **Scope:** Electro-intensive businesses in sectors facing international competition can apply to pay a lower EEG surcharge. **Facts and figures:** In 2016, 2,044 businesses in the manufacturing industry with an electricity consumption of 96 TWh received privileges under the special compensation arrangements (BAFA 2016).

	Instrument	State of implementation
144.	Reductions in the CHP surcharge	**Goal:** The aim is to ensure that German businesses are not put at a disadvantage in relation to international competitors, and that jobs are therefore not lost, as a result of the promotion of combined heat and power in Germany. **Scope:** Electricity consumers with more than one GWh of electricity consumption, and certain highly electro-intensive businesses and rail operators pay a lower CHP surcharge. **Facts and figures:** According to the forecast data of the transmission system operators, a lower CHP surcharge was paid for 206 TWh in 2015, as the final consumers drew over one GWh of electricity. In addition, the CHP surcharge was limited for an additional 87 TWh as this energy could be assigned to electro-intensive businesses. Total relief amounted to €493 million. This system is being reorganised with effect from 2016 and the rules for special compensation arrangements under the Renewable Energy Sources Act will also apply under the CHP Act.
145.	Relief under the Energy Tax Act and Electricity Tax Act	**Goal:** the mandatory tax relief, partly attributable to EU law, serve various purposes, for example ensuring competitiveness in the international league tables (lowering energy costs) or environmental protection (e.g. tax cuts for local public transport or CHP plants). **Scope:** Businesses can apply for tax relief on various legal grounds (e.g. relief for particularly energy-intensive or electro-intensive processes, general energy tax and electricity tax relief for the manufacturing industry, tax capping). Energy efficiency requirements must also be met to qualify for the tax cap mechanism (certification to ISO 50001 or EMAS enrolment; tax relief for SMEs). **Status:** According to current information, 23,797 companies have benefited from energy tax relief, and 46,938 companies from electricity tax relief. **Facts and figures:** Energy tax relief amounted to €878 million in 2016, while electricity tax relief amounted to €3.5 billion.
146.	CO_2 allowance price and free allocation, in some cases, in the EU emissions trading system	See Chapter 3
147.	Relief from grid charges	**Goal:** The Network Charges Modernisation Act (NEMoG) gradually reduces regional disparities in transmission grid charges, creates more distribution equality and reduces network costs. **Scope:** Transmission grid charges will be aligned nationwide, starting in 2019, in five steps. Offshore connection costs will no longer be financed with grid charges starting in 2019, rather with a levy. Payments made by distribution network operators to power producers for avoided grid fees will be gradually removed, thus lowering distribution network costs. **Status:** The Network Charges Modernisation Act entered into force July 2017. **Facts and figures:** The cost burden carried by the distribution networks for payments for avoided grid charges was reduced from 2017 to 2018 by over €1 million, according to preliminary figures.
	Chapter 11: Environmental compatibility of the energy supply system	
148.	Distance between residential areas and wind power plants in compliance with the Technical Instructions for Noise Protection	**Goal:** Rules on maintaining distance from wind power plants **Scope:** Measurement and assessment of low-frequency noise immissions in accordance with Numbers 7.3 and A.1.5 of the technical instructions.
149.	Drafting a general administrative regulation on minimization of electrical and magnetic fields created by newly erected and substantially modified electricity supply installations and similar plants	**Goal:** Preventative minimization of electric and magnetic fields in relevant areas in accordance with technological developments **Scope:** Catalogue of technical measures to be implemented when erecting or substantially modifying electricity lines and ancillary installations with a nominal voltage of 1,000-2,000 volts, and monitored using a predetermined evaluation plan **Status:** 26 February 2016, the 26th Regulation on Implementation of the Federal Immission Control Act entered into force (26. BImSchVVwV).
150.	Initiation of a research programme on radiation protection accompanying the expansion of the power grid.	**Goal:** Continued improvement of risk assessment and communication regarding static and low-frequency electrical and magnetic fields that occur during transmission and use of electricity **Scope:** Investigating a possible connection between low frequency magnetic fields and neurodegenerative illnesses; setting perception and effects thresholds; determining causes of leukemia in childhood; co-cancerous effect of exposure to magnetic fields; research on a possible connection between exposure to magnetic fields and miscarriages; investigation of the occurrence, expansion and absorption of corona ions; exposure analysis, evaluation and current data for the general public; risk awareness and risk communication **Status/Facts and figures:** Kick-off event for the research programme in July 2017 with subsequent online discussion, total of 35 projects of which several workshops and projects have already been completed or initiated
151.	German Resource Efficiency Programme II	**Goal:** Extract mineral and fossil resources in a more climate-friendly manner; strengthen environmental, social and transparency standards in the international resources sector and create more sustainable supply chains; emphasize compliance with social and ecological minimum requirements in production and in supply chains of resources and goods imported into Germany; support for companies that encourage sustainable supply chain management **Scope:** The recommendations in Programme II for managing resources refer to the resource demands of energy plants. Numerous new developments have been applied to strengthen sustainability in relevant and suggestions from Programme II are put to good use. Ecological aspects have hardly been taken into consideration, despite the need for action in conserving natural resources and despite the strong connection between environmental pollution and social and human rights conflicts. **Status:** Specific implementation in many instances still has not taken place. The effectiveness of this programme can therefore not be assessed.

	Instrument	State of implementation
	Chapter 12: Grid infrastructure	
152.	Network Charges Modernisation Act	**Goal:** This Act gradually equalises transmission grid charges by 2023. As of 1 January 2023, the charges for transmission networks will be the same everywhere in Germany. Furthermore, the Act provides for the removal of avoided network charges. **Scope:** See No. 147 **Status:** Entered into force July 2017
153.	Revision of the Incentive Regulation Ordinance	**Goal:** Improve investment conditions for distribution grids and strengthen incentives for efficiency, while keeping the costs for consumers to a minimum and increasing transparency. **Scope:** A capital expenditure true-up will be introduced for distribution system operators. This instrument will take account of decreasing capital costs of existing plants over the regulatory period. Because the value on which interest is based declines due to declining residual values, the income of grid operators also declines (low return on equity). New publication obligations render the decisions of the regulation authorities and the costs and revenues of the TSOs more transparent. **Status:** Entered into force September 2016. The true-up of capital expenditure will apply as of the 3rd regulatory period, i.e. as of 2019 (electricity) or 2018 (gas).
154.	Federal Requirements Plan Act	**Goal:** Legal basis for the necessity of meeting energy supply requirements and the great need for new transmission lines **Status:** The act was most recently amended in December 2015 with the Act to Amend Provisions of Law on Energy Grid Construction (inclusion of additional projects from the 2024 Grid Development Plan). The newly approved network optimisation, reinforcement and expansion plans provided for in the 2017–2030 Grid Development Plan are also to be included in the Federal Requirements Plan Act. Adoption of the amending legislation is planned for 2019.
155.	Amendment of the Grid Expansion Acceleration Act	**Goal:** Acceleration of grid expansion, inter alia by simplifying the approval procedure **Scope:** Several amendments to the law are planned, which should in particular simplify and speed up the approval procedure for network optimisation measures. **Status:** Ministerial draft is planned for 2018. These amendments can build on results from the dena/BET stakeholder process for improving electricity grid loads and from the working group subsequently formed to simplify and accelerate approval procedures.
156.	Power Grid Expansion Act	**Scope:** The Power Grid Expansion Act defines the high priority given to the need for expansion and the necessary to meet energy supply requirements with 22 projects. Six of the projects can be realised on sub-loops as pilot projects for the use of underground cables at the ultra-high voltage level. **Status:** The Act was already adopted in 2009 by the Bundestag and the upper house, and most recently amended in 2015 with the Act to Amend Provisions of the Law Governing Power Line Construction (expansion of ground cable pilot projects).
157.	Act to Amend Provisions of the Law Governing Power Line Construction	**Status:** The Act entered into force July 2016. For large 'electricity motorways' (= new ultra-high voltage-direct current-transmission lines) the use of ground cable is established as a planning principle in federal sectoral planning new EHV-DC lines. The goal is to increase acceptance of grid expansion; only if the local population accepts such construction will grid expansion succeed. In the case of AC or three-phase power lines, the number of pilot routes for underground cabling is increased and the criteria for underground cabling expanded. Key grid expansion projects from the 2024 Grid Development Plan that has been approved by the Federal Network Agency are ultimately given a legal basis in the Federal Requirements Planning Act.
158.	Continued development of the monitoring of German grid expansion projects as well as monitoring of measures to increase utilization of the electricity grid	**Goal:** Create transparency and awareness among all stakeholders with regard to realistic planning and implementation assumptions, and identify delays in grid expansion at an early stage. Making better use of existing capacity is also important. **Scope:** Previously concentrating on projects under the Power Grid Expansion Act, the quarterly Monitoring Report published by the Federal Network Agency (www.netzausbau.de) was refined with effect from the first quarter of 2016. In future a separate report will be published for projects under the Power Grid Expansion Act (22), the Federal Requirements Planning Act (43) and offshore projects (24), along with a summary bar chart, to indicate progress in the planning and approval procedure for the individual projects. In addition, the bar chart for projects under the Power Grid Expansion Act and Federal Requirements Planning Act also indicates the planned launch dates. In the Power Grid Expansion Act reports and the Federal Requirements Planning Act reports, as of the fourth quarter 2017, projects are also marked either as grid expansion or grid reinforcement projects. In the 2nd or 3rd quarter of 2018, monitoring will also include measures for optimising existing networks (e.g. using available grid monitoring or high-temperature conductors) that should help to quickly increase transmission capacity of existing networks.
159.	Further development of the Ordinance on Agreements Concerning Interruptible Loads	**Goal:** Ensure grid stability and therefore security of supply **Scope/status:** Interruptible loads are industrial operations that continuously consume a large volume of electricity and which, when called upon, can temporarily 'interrupt/reduce' their demand. The procurement and use of interruptible loads has undergone continued, consistent development since the previous regulation that was in place. In particular, the procurement process has become more competitive and the framework to utilise interruptible loads has been extended and optimised. The revised version of the Ordinance entered into force on 1 October 2016. The European Commission has confirmed that it complies with European rules on state aid. **Facts and figures:** As of May 2018, suppliers with a total of 1,110 MW capacity are pre-qualified for participation.

	Instrument	State of implementation
160.	Electricity Market Act	See No. 132
161.	Act on the Digitisation of the Energy Transition	See No. 168
162.	Electricity price compensation	**Goal:** Prevent manufacturing from moving abroad. **Scope:** Since the start of the third trading period, businesses whose production processes are highly electro-intensive and that are at risk of moving production abroad (carbon leakage) – because of high costs due to CO_2 emissions from electricity generation – can apply for compensation for the costs they incur as a result of the indirect CO_2 costs of the EU emissions trading scheme which are passed on in electricity prices. The amount of compensation is based on the CO_2 allowance price for the specific accounting period. **Facts and figures:** For the accounting year 2016 (disbursement 2017), assistance was approved for 902 industrial plants, as a result of which support amounting to €289 million was disbursed.
163.	'Civil Dialogue on the Power Grid' initiative	**Goal:** The Civil Dialogue on the Power Grid initiative strives to facilitate an open and transparent dialogue between all parties involved in power grid expansion. **Scope:** To this end, the initiative provides basic information on grid expansion early on, and gives citizens advice on how to participate. Staff provide information nationwide in Bürgerbüros (citizens bureaus), at events, weekly markets, in front of city halls or in pedestrian zones, as well as online, regarding the relationships between grid expansion and the energy transition. b: The BMWi has been financing the Initiative since 2015. Information events take place regularly in the affected regions. **Facts and figures:** In addition to a Dialogmobil, the Initiative has over ten offices in all of Germany.
164.	dena Ancillary Services Platform	**Goal:** Further development of the ancillary services required for the energy transition **Scope:** Stakeholder platform run by dena, in which market players such as manufacturers and network and plant operators as well as the BMWi participate.
	Chapter 13: Integrated development of the energy system	
165.	Electric mobility eco-bonus	see Chapter 7
166.	Low temperature heat networks with seasonal thermal energy storage ('Model project heat networks systems 4.0')	see No. 48
167.	Promotion of innovative CHP systems under the CHP Act	see No. 135 (Combined Heat and Power Auction Ordinance)
168.	Act on the Digitisation of the Energy Transition	**Goal:** Creating the technical framework for demand side and generation management measures and for more flexibility in the power grid **Scope:** Introducing smart metering systems: Smart Grid, Smart Meter, Smart Home. These are to serve as a secure communication platform to create a stronger network for the energy supply system. **Status:** Entered into force September 2016
169.	Ordinance for creating a legal framework for collecting knowledge in the funding programme titled Smart Energy Showcases – Digital Agenda for the Energy Transition (SINTEG Ordinance)	**Goal:** Broad-scale solutions for technology, economic and regulatory issues facing energy supply of the future **Scope:** The main emphasis is digitisation of the energy sector. The SINTEG Ordinance has created numerous simplifications and possibilities for programme participants. **Status:** Entered into force 21 June 2017
170.	Energy Savings Meter pilot programme	see Chapter 5
	Chapter 14: Energy research and innovation	
171.	Consultation on the 7th Energy Research Programme of the Federal Government	**Goal:** Contribution to implementing the energy transition **Scope/Status:** A new energy research programme was created in the period 2016/2017 using a consultation procedure and system analysis research as part of strategic flagship projects (documented at www.energieforschung.de). **Facts and figures:** From 2013 to 2016, €3.6 billion in total were provided to promote research and development. In 2016 alone, €876 million was spent.
172.	Horizon 2020 / Research and Innovation Framework Programme	**Goal:** Enhancing Europe's competitiveness **Status:** Horizon 2020, the European research and innovation framework programme, commenced in 2014. **Facts and figures:** Around €5.9 billion was allocated for the 2014-2020 funding period for 'safe, clean and efficient energy' in the area of non-nuclear energy research.

	Instrument	State of implementation
173.	Energy transition - Research and Innovation platform (R&I platform)	**Goal:** Exchange and dialogue with representatives of the government, the business community and academia for further development of energy research, as well as to accelerate transfer of results of energy research into practice **Scope:** Discussions take place on current developments in energy research, in particular new formats and scope of research funding. Issues that need to be addressed at shorter notice are discussed in flexible ad hoc working groups. In addition, the platform pools and coordinates the energy research networks (see no. 176). **Status:** Plenary sessions of the R&I platform have been held twice annually since early 2015. At the end of 2016, the R&I Platform was the forum for the consultation procedure for the new Energy Research Programme. Instead of the spring conference, on 2 May 2017 an official ceremony took place for the 40th anniversary of the Energy Research Programme, followed by a conference on the future of energy research in Germany. On 28 November 2017 expert recommendations from research networks were presented as a contribution to the consultation procedure for the new Energy Research Programme.
174.	Energy Research Networks	**Goal/Scope/Status/Facts and figures:** The BMWi Energy Research Networks comprise around 2,800 members. There are currently seven Energy Research Networks: Renewable Energies, Flexible Energy Conversion, Electricity Networks, Energy System Analysis, Bioenergy, ENERGIEWENDEBAUEN and Energy Efficiency in Industry and Commerce. These networks represent the broad research landscape in Germany. They supply valuable impetus to important research topics from the perspective of science and research, and provide a platform for connecting researchers, business and government. In addition to participation and transparency, the research networks should provide a stronger impetus for rapid transfer of research results to the energy sector. As part of the consultation procedure for a 7th Energy Research Programme, the Energy Research Networks grouped members into topic-related task groups that provided strategy input and expert recommendations. These relate both to further development of federal energy research policy and to the relevant need for funding and future use of various energy and efficiency technologies.
175.	Energy Transition Research Forum	**Goals:** Key players from the Länder, the business community, academia and civil society have been meeting since 2013 to drive forward the effective coordination and long-term direction of energy research. **Scope:** Conclusions are reached with regard to the structures, instruments and future topics of research policy.
176.	Funding initiative 'Energy Transition Copernicus Projects'	**Goal:** The four Copernicus projects will facilitate the move from basic research to practical application in four key areas of the energy transition. In the first phase of funding the aim is to create the basis for a technologically outstanding and economically competitive energy system which also enjoys the greatest possible level of public acceptance. **Scope:** Each of the four projects addresses a core issue of the energy transition: electricity networks with high shares of renewable energy (ENSURE); storage and conversion of renewable electricity (P2X); reorienting industry processes to fluctuating energy supplies and sector coupling (SynErgie); and system integration (ENavi) **Status:** The four Copernicus projects ENSURE, P2X, SynErgie and ENavi involve 260 project partners and started in 2016. The first funding phase runs until 2019. **Facts and figures:** The funding amount is estimated at over €120 million.
177.	Carbon2Chem research project	**Goal:** Conversion of blast-furnace gas from steel production into base chemicals using renewable energy. **Scope:** Valuable chemical primary products for fuels, plastics or fertilizers that replace fossil fuels are produced from blast furnace gas. Thanks to the project, 20 million tonnes of annual CO_2 emissions from the German steel industry can be used commercially. **Status:** This project is currently receiving funding. **Facts and figures:** The Federal Ministry of Education and Research will make more than €62 million available for project in the next four years.
178.	'Energy Systems of the Future' Academies' project	**Goal/Scope/Status/Facts and figures:** 120 representatives from German science academies develop systemic policy options for the area of basic research with a focus on the energy system of the future, and in doing so provide a scientifically sound basis for society-wide debates on issues that are of medium- to long-term relevance to a successful energy transition. In addition to questions about technological feasibility, the project also addresses economic and legal issues, as well as aspects regarding the efficient use of resources and public acceptance.
179.	'Sustainable Power Grids' research initiative	**Goal/Scope:** Joint initiative of the Federal Ministry for Economic Affairs and Energy and the Federal Ministry of Education and Research to create the necessary technological framework for the future transmission and distribution of electricity to create a reliable, affordable and environmentally friendly power supply system **Facts and figures:** Around 300 projects since 2014 with funding of €150 million

	Instrument	State of implementation
180.	'Solar Construction/Energy-efficient Cities' funding initiative	**Goal:** Joint initiative of the Federal Ministry for Economic Affairs and Energy and the Federal Ministry of Education and Research concerning new technologies and strategies for better energy efficiency and the integration of renewables in order to move the energy transition forward in buildings and urban areas **Scope:** Module I (BMWi): Focus on demonstrating ideas for retrofitting and new construction of residential buildings with more than one floor; Eight collaborative projects started work in Module I in 2017. Module II (BMWi and BMBF): Comprehensive and systemic flagship projects at the urban quarter level in Esslingen, Heide (Holstein), Kaiserslautern, Oldenburg, Stuttgart/Überlingen and Zwickau. In Module II five of the six flagship projects selected were launched in 2017. The sixth project started early 2018. **Facts and figures:** Module: approx. €20 million For Module II, BMBF and BMWi each pay one-half of the over €100 million being provided.
181.	'Research Campus – Public private Partnership for Innovation' (Mobility2Grid and Flexible Electrical Networks research campuses)	The Federal Ministry of Education and Research funds cooperation between the scientific community and business in energy research with the Mobility2Grid and Flexible Electrical Networks research campuses: • **Mobility2Grid research campus** **Goal:** Integrating commercial and private e-vehicles in decentralised energy grids based on renewable energy resources **Scope:** Creating a reference urban quarter in Berlin-Schöneberg with research and industry stakeholders for synergetic interworking of electric mobility, electric and heating supply networks **Status:** Funding started in January 2016, with the first five-year main phase. **Facts and figures:** The Federal Ministry of Education and Research is providing up to €10 million for the first main phase. • **Flexible Electrical Networks research campus:** **Goal:** Research of innovative technologies for electrical networks using a high percentage of regenerative and decentralised energy sources **Scope:** The research campus in Aachen is a joint effect of RWTH Aachen University and industry stakeholders. Transdisciplinary research is focused on the development and integration of direct current technologies. **Status:** Funding started in October 2014, with the first five-year main phase. **Facts and figures:** The Federal Ministry of Education and Research is providing up to €10 million for the first main phase.
182.	National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)	**Goal:** Joint initiative of the Federal Ministry for Economic Affairs and Energy, the Federal Ministry of Transport and Digital Infrastructure, the Federal Ministry of Education and Research and the Federal Ministry for the Environment as well as industry and the scientific community, designed to speed up technology development and the process of producing marketable products based on these technologies **Status:** Approval of the follow-on programme at the end of 2016 **Facts and figures:** More than 200 research projects with around €1.4 billion for the period 2007 to 2016
183.	Hydrogen and Fuel Cell Technology Government Programme for the 2016–2026 funding period (NIP 2)	**Goal:** The goal is to bring products and applications based on hydrogen and fuel cell technology to the market. **Scope:** The focus is on continued technological advances to create competitive products. Planned investment on the part of industry is supported by public-sector funding. **Facts and figures:** Budget of around €1.4 billion for the period 2016 to 2026
184.	Programme collaboration: Energy Transition Research Alliance at the German Federation of Industrial Research Associations (AiF)	**Goal/Scope:** Joint initiative of energy research and industrial collective research launched by the Federal Ministry for Economic Affairs and Energy to specifically strengthen the innovative capacity of non-research-focussed SMEs in the development of energy solutions **Status:** First projects started at the end of 2016. **Facts and figures:** An additional €18 million in funding will be available from 2016.
185.	Renewable Resources funding programme	**Goal:** Initiative of the Federal Ministry of Food and Agriculture for the promotion of research, development and demonstration projects in the use of renewable resources as materials and for energy purposes **Facts and figures:** €61 million were available in 2016. In addition, funding of €24.6 million will be provided from the Energy and Climate Fund for bioenergy projects.
186.	'Biomass Energy Use' funding programme	**Goal:** Research and development work, with a practical orientation, on forward-looking technologies and the optimisation of processes which enable the efficient, economic and sustainable use of bioenergy and help contribute to security of supply **Scope:** Support granted in particular to solutions with a practical orientation that are promising for demonstration projects and pilot schemes and help flexibilise the generation of electricity and heat using biomass. In particular, the aim is to tap the potential of biomass by-products and waste to improve sustainable energy-related use in the (coupled) heating and electricity sectors. **Status:** Programme launched in 2009 and reorganised in 2015. **Facts and figures:** So far there have been 300 individual projects, mostly collaborative projects, with funding amounting to around €44 million. €61 million were available in 2016. In addition, funding of €24.6 million will be provided from the Energy and Climate Fund for bioenergy projects.

	Instrument	State of implementation
187.	'Energy Storage' research initiative	**Goal:** Joint initiative of the Federal Ministry for Economic Affairs and Energy and the Federal Ministry of Education and Research to support research and development projects starting with basic R&D work on up to demonstration projects geared towards practical application **Scope:** http://forschung-energiespeicher.info/ **Facts and figures:** Around 250 projects and €200 million since 2012
188.	WIPANO – Knowledge and Technology Transfer via Patents and Standards	**Goal:** Promotion of public research, support for companies to help them patent and exploit their ideas, and support for innovative projects **Scope:** To promote patenting, some of the costs are covered for patent advice, consulting a patent attorney or for filing the patent. **Status/Facts and figures:** The measure is in place from 1 January 2016 to 31 December 2019 with a budget of €23 million. Businesses, high-education institutes, universities and non-university research centres are eligible to apply.
189.	Promotion of stationary fuel cell heating as part of the Energy Efficiency Incentive Programme	**Goal:** Support the introduction of fuel cell technology in the heating and electricity supply systems of residential buildings **Scope:** Funding is granted for the installation of fuel cell systems with a capacity of between 0.25 kWel and 5 kWel in residential buildings if the fuel cell is incorporated into the building's heating and power supply system. Both new buildings and energy retrofits in existing buildings are eligible for support. Support is provided in the form of a grant and can be combined with funding under the CHP Act. **Facts and figures:** A total of €150 million is available annually in the period 2016–2018 for investment support measures under the Energy Efficiency Incentive Programme (heating package, ventilation package and fuel cells).
190.	New Vehicle and System Technologies funding programme	**Goal:** Improving the innovative potential and competitiveness of the German automotive industry **Scope:** Financial support for practical technology innovations in the two programme areas, Automated Driving and Innovative Vehicles, in particular regarding lightweight construction and modern drivetrains **Status:** Various ongoing funding projects on reducing weight, waste heat recovery, improving the combustion concept and using electricity-based fuels **Facts and figures:** Total funding €45 million annually for each programme area

If measures described in the table above are also measures funded under the 2020 Climate Action Programme, detailed information on their state of implementation is provided in the annual climate reports issued by the Federal Government.

The measures are implemented under the applicable budgetary and financial planning principles of the ministries (including positions and permanent posts) subject to the availability of the necessary budget funds.

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List of abbreviations

AA	Federal Foreign Office
AGEB	Working Group on Energy Balances
AGEE-Stat	Working Group on Renewable Energy Statistics
AiF	German Federation of Industrial Research
APEE	Energy Efficiency Incentive Programme
BAFA	Federal Office for Economic Affairs and Export Control
BET	Office for the Energy Industry and Technical Planning GmbH
BLE	Federal Office for Agriculture and Food
BMBF	Federal Ministry of Education and Research
BMEL	Federal Ministry of Food and Agriculture
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
BSI	Federal Office for Information Security
CDM	Clean Development Mechanism
CEER	Council of European Energy Regulators
CH_4	Methane
CHP	Combined heat and power (CHP)
CHPA	Combined Heat and Power Act (CHPA)
CNG	Compressed natural gas
CO_2	Carbon dioxide
COM	European Commission
COP21	21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change
ct	cent
dena	German Energy Agency
DIW	German Institute of Economic Research
DLR	German Aerospace Center
DPMA	German Patent and Trademark Office
EDL-G	Energy Services Act
EEA	European Environment Agency
EED	Energy Efficiency Directive
EEG	Renewable Energy Sources Act
EEWärmeG	Renewable Energies Heat Act
EEX	European Energy Exchange
EnEG	Energy Conservation Act
EnEV	Energy Conservation Ordinance
EPBD	EU Energy Performance of Buildings Directive
ESD	Effort Sharing Decision
ESG	Energy Efficiency Strategy for Buildings
ETS	Emissions Trading System
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
GVFG	Local Authority Transport Infrastructure Financing Act
GWS	Institute of Economic Structures Research
HDV	Heavy duty vehicles
HZO	Programme for Promotion of Heating Optimisation Using High-Efficiency Pumps and Hydraulic Balancing
IAEW	Institute of Power Systems and Power Economics, RWTH Aachen
ICT	Information and Communication Technology
IEA	International Energy Agency, Internationale Energie Agentur
IFAM	Fraunhofer Institute for Manufacturing Technology and Advanced Materials
ifeu	Institute for Energy and Environmental Research, Heidelberg
IRENA	International Renewable Energy Agency
JI	Joint Implementation
KfW	Reconstruction Loan Corporation
km	Kilometre
kW	Kilowatt
KWKG	Combined Heat and Power Act
LNG	Liquefied Natural Gas
MAP	Market Incentive Programme for Renewable Energies
MSR	Market Stability Reserve
NAPE	National Action Plan on Energy Efficiency
NEMoG	Network Charges Modernisation Act
NIP	National Innovation Programme for Hydrogen and Fuel Cell Technology
PJ	Petajoule
PV	Photovoltaic
R&D	Research and development
REN21	Renewable Energy Policy Network for the 21st Century
RES	Renewable energy sources
SAIDI	System Average Interruption Duration Index
SINTEG	Smart Energy Showcases – Digital Agenda for the Energy Transition
SME	Small and medium-sized enterprises
StBA	Federal Statistics Office
t	Tonne
TCP	Technology Collaboration Programme of the IEA
tkm	Tonne-kilometre
TWh	Terawatt hour
UBA	Federal Environment Agency
WLTP	World Harmonised Light Vehicle Test Procedure
ZSW	Centre for Solar Energy and Hydrogen Research Baden-Württemberg

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