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Switch to the Future

Second Progress Report on the Energy Transition

The Energy of the Future

Reporting Year 2017 – Summary –

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Central messages from the Second Progress Report on the Energy Transition

The German Federal Government has set itself ambitious goals with its energy transition. It is a vehicle for Germany to plan a sustainable energy supply and to provide the economy and industry new opportunities to create additional value added. The energy transition is not solely a German effort, rather is embedded in European energy policy and has meanwhile taken root all over the globe. To be successful, the energy transition must therefore also be seen from a global and holistic perspective. To this end, the German Federal Government is taking the measures described in this report and is utilizing market processes to implement the energy transition to meet the goals it has set, both technology-neutral and cost efficiently.

At the European level, the 'Clean Energy for All Europeans' package has in particular successfully set the course for the energy transition in Europe and Germany. This package has set ambitious goals for 2030 and beyond. The whole EU is basically on course to reach its energy and climate goals for 2020. With a view to reducing greenhouse gases, both the sectors falling under the European emissions trading system (EU-ETS), and the non-ETS sectors have already fulfilled their respective targets of 21% and 10% reductions in emissions.

→ The Federal Government submitted a draft for an integrated National Energy and Climate Plan (NECP) in December 2018. After conducting consultations, it will submit a final Plan at the end of 2019. The Plan will set out how Germany aims to achieve its national energy and climate goals for 2030 and, accordingly, contribute to the goals of the Energy Union.

The Federal Government set up the Commission on Growth, Structural Change and Employment ("Coal Commission") in the summer of 2018, with actors from various economic and social groups. The Coal Commission presented its final report on 31 January 2019. In this report it makes recommendations for meeting the 2030 targets for the energy sector set out in the 2050 Climate Action Plan, among other things. This also includes the gradual reduction and finally, phasing out, of coal-fired power generation by 2038 at the latest. The reduction in greenhouse gas emissions in the period 2023–2030 should be continuous, if possible. The cut-off date should be reviewed in 2026, 2029 and 2032, and either brought forward or adjusted. At the same time, the Coal Commission made recommendations for assisting coal regions in future-oriented, sustainable structural development. The Federal Government is reviewing these recommendations. At the national level, the Federal Government adopted key parameters on 22 May 2019 for implementing the structural policy recommendations of the Coal Commission.

The following facts and figures on the status of selected German energy and climate goals show the difficulty of this challenge and the measures the Federal Government is taking to tackling it.

A positive piece of news is that the share of renewable energies in gross electricity consumption was 36% in 2017. This increase continued in 2018. 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. The cost of producing electricity from renewable energy resources was significantly reduced for many new facilities. An important factor in this was the successful bidding competition with sufficient approved land for wind and photovoltaics.

Targeted, efficient, grid-synchronized and an increasingly market-driven expansion of renewable energy sources is a prerequisite for successful energy transition and climate protection policies. The Federal Government aims to increase the share in renewables in the energy sector – especially in the context of the challenges of better synchronisation of renewable energy sources and grid capacity – in order to reach the goal set by the coalition agreement of approximately 65% by 2030. The capacity of the power grid to transport energy is key.

→ The Omnibus Energy Act created special bidding processes for onshore wind energy and photovoltaics for an additional 4 gigawatts up to 2021 and provides for innovation bidding processes.

→ By the autumn of 2019, based on the grid expansion plan and the results of the coalition working group on issues of acceptance and of the Coal Commission, decisions should be made regarding specific acceptance measures and requirements for funding, and regarding future routes for expansion of renewable energy sources in the electricity sector by 2030, in order to reach the 65% goal set in the Coalition Agreement.

Primary energy consumption in 2017 increased by 0.8% compared with the previous year. This was primarily due to strong economic growth. In contrast, primary energy consumption declined in 2018, according to preliminary estimates. However, annual energy savings of 0.6% on average since 2008 and positive figures for 2018 are not sufficient to reach the target set for 2020 (20% reduction). Overall, there is a great need to take action to achieve the savings target as quickly as possible.

→ The Federal Government plans to present an energy efficiency strategy in 2019. This strategy aims to introduce a 2030 efficiency target and a specific catalogue of measures for the decade 2021-2030 (NAPE 2.0), which should also be instrumental in achieving the German contribution to the EU energy efficiency goal for 2030.

Energy consumption in buildings in 2017 increased by 2.6% compared with the previous year. Since 2008, this figure had declined by an average of 0.8% annually. To reach the savings target as quickly as possible, there must be additional effort in this area, too. The Federal Government will prepare a catalogue of measures for the buildings sector to achieve the 2030 targets set for this sector, and will add these measures to the National Energy and Climate Plan and the 2030 Programme of Measures for implementing the 2050 Climate Action Plan.

→ The Federal Government will draft a new bill for energy conservation law for buildings, and will combine the Energy Conservation Act, the Energy Conservation Ordinance and the Renewable Energy Sources Act into the Buildings Energy Act. As set forth in the Coalition Agreement, the Buildings Energy Act will remove bureaucracy and simplify regulations, will transpose EU legislation and provide continuity in energy requirements for old and new buildings. In addition, the 'urban quarters' approach will be introduced.

→ The tax incentives for energy efficient refurbishment of buildings is a top priority measure that was set out in the Coalition Agreement to contribute to achieving the energy and climate policy goals in the buildings sector. The Federal Government is reviewing various options of implementation that will comply with budgetary requirements of the coalition agreement.

→ It has implemented an assistance programme titled "Energy Efficiency and Heating with Renewable Energy" to give funding programmes more focus and visibility and make access significantly easier. The German Federal Government prioritizes effective use of funds to make such instruments basically more efficient.

Final energy consumption in the transport sector continued to run counter to the goals of the Energy Concept, increasing by around 2.4% compared with the previous year and around 6.5% compared to 2005. It is expected that the 2020 Goal (10% reduction) 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.

→ The German Federal Government initiated the National Platform on Electric Mobility. This platform aims to assess future mobility issues and formulate recommendations for action in the areas of climate protection in the transport sector, alternative drives and fuels, digitisation, securing Germany as a centre of mobility and manufacturing, infrastructure and grids, and standardisation. Working Group 1 deals with climate protection in the transport sector, and submitted an interim report in March 2019 to the steering committee of the National Platform on Electric Mobility.

Greenhouse gas emissions went down slightly in 2018 according to preliminary estimates. In 2017 they had declined by 27.5% compared with 1990.

→ The German Federal Government is assessing what additional action should be taken in order to reach the climate protection goal for 2020 (40% less greenhouse gases compared with 1990) as quickly as possible. The Coal Commission has prepared recommendations for gradual reduction and phase-out of coal-powered power generation, sustainable and future-oriented structural development, as well as recommendations on how the energy sector can contribute as best as possible to bridging the remaining gap to the climate goal for 2020.

→ The Federal Government is working on a 2030 Programme of measures for the 2050 Climate Action Plan that will also be incorporated in the NECP. These measures should ensure that the reduction target for 2030 (at least 55% less compared with 1990) is reached and all sectors contribute to this target. The Coal Commission has developed recommendations for meeting the 2030 targets for the energy sector set out in the 2050 Climate Action Plan. All of the measures are evaluated with regard to their ecological, economic and social impact. As agreed in the Coalition Agreement, the German Federal Government will draft a law that will enforce compliance with the 2030 climate targets.

→ The Cabinet resolved in March 2019 to set up a Climate Protection Cabinet Committee to ensure the legally binding implementation of the Climate Action Plan as well as of the climate protection targets for 2030 binding on Germany.

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. The European electricity market also contributes to this security. Germany is at the forefront – also by international standards – with supply quality consistently at a very high level. This high level of security will also be maintained in the event of atomic energy and coal phase-out.

Cost efficiency is one of the main criteria for optimal implementation of the energy transition. Electricity in particular must remain affordable and German industry must remain competitive. In light of this, efforts have been made to appreciably slow down the EEG surcharge dynamics of previous years. Electricity prices for private households remained nearly constant in 2017 and 2018. However, for industrial customers not covered by special compensation arrangements, electricity prices increased by 4.9% in 2017. An increase was also recorded in 2018. For a hypothetical electricity consumer who can take advantage of all existing discounts, after adding up all factors, electricity prices increased in 2017 by 0.7% in 2017 and by 8.4% in 2018, according to the Federal Network Agency and the Federal Cartel Office.

Final consumers spent more overall in 2017 for final energy than in the previous year. The share of end energy expenditures in nominal GDP was unchanged over the previous year, at 6.7%. The share of electricity costs in GDP declined once more in 2017, and reached the lowest level since 2010.

The grid expansion measures that have been agreed must be implemented without delay.

→ 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. In January 2019, formal federal sectoral planning for the first phase of the large ultra-high voltage grid Ultranet was completed.

→ The Action Plan Electricity Grid of the Federal Ministry for Economic Affairs and Energy contains two strategies: first, existing grids should be optimized and utilized more heavily and grid expansion should be accelerated. Technical improvements, new technologies and operating concepts as well as improved management of shortages will optimize existing grids. At the same time, grid expansion should be accelerated with strategic controlling, simplifying the planning process and economic incentives. The German Bundestag passed the Power Grid Expansion Act (NABEG amendment) in April 2019. The Action Plan will be further developed in the coming months and specific measures will be incorporated.

Digitalisation, the heating transition, sector coupling and energy research are additional key factors in making the energy transition successful. Integrated development of the energy system is essential. To achieve this, the framework must be quickly adapted and planning reliability ensured.

→ A barometer on digitisation of the energy transition has been introduced by the Federal Ministry for Economic Affairs and Energy to determine the progress made in specific areas. At the same time, there is work to be done yet on implementation of the Act on the Digitisation of the Energy Transition (GDEW). The first certification of a Smart Meter Gateway in December 2018 marks an important milestone.

→ The German Federal Government will continue to promote the heating transition – indispensable for achieving energy and climate targets. This includes creating new heat networks, but also modernising existing heat networks, stronger emphasis on renewable energy in heating supplies and increasing energy efficiency.

→ A substantial impetus for sector coupling is the “Gas 2030 dialogue process” launched in December 2018 with representatives from the gas sector. Findings are expected in September 2019.

→ The 7th Energy Research Programme addresses current and expected challenges with a holistic approach to funding policy. Current financial planning has earmarked approximately €6.4 billion for energy research under this program for the period 2018 to 2022. Living labs for the energy transition will support the transfer of practical results and startups will provide important impetus for the energy transition.

The energy transition is a modernisation strategy that will trigger extensive and ongoing future investment in enhancing Germany’s attractiveness for business and investment – particularly in the areas of energy-efficient refurbishment of buildings, the energy supply and transitioning to e-mobility – and thereby contribute to increased growth and employment in Germany. 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. Certain industry sectors and business models are faced with structural change, and need assistance.

Many German companies profit from trade in new and innovative energy technologies. For example, in 2017, exports of renewable energy installations and components amounted to over €8 billion. Global demand for well-designed renewable energy installations and efficient technologies is on the rise, which improves business prospects in this area. 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 of the energy transition with a view to establishing a secure, environmentally friendly and economic energy supply and checks the implementation of measures to transition the energy system; the German energy transition is embedded in the European energy transition and its ambitious goals. 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 Second Progress Report focusses on these tasks. It

- is based on data taken over several years to ensure reliable trend analysis;
- contains a comprehensive comparison of status quo and quantitative and qualitative goals of the Energy Concept;

- describes and evaluates the status of implementation of important measures;
- pan overview of the expected development of important key indicators and describes:
  - updated 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;
  - results from the reference scenario of the "Energy Sector Projections and Impact Assessment"
- examines causes and explains hurdles
- recommends measures or processes for removing hurdles and reaching targets.

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. The Monitoring Report is an integral part of this Report.

The boxes below provide an overview of important horizontal issues of the Report.

From the electricity transition to the Energy Transition – paving the way for 2030

The energy transition pursues ambitious goals. The energy transition is a vehicle for Germany to plan a sustainable energy supply and to provide the economy and industry new opportunities to create additional value added. The energy transition is not solely a German effort, rather has meanwhile taken root all over the globe and is embedded in European energy policy. Major measures taken up to now started with the nuclear energy phase-out by 2022, and most recently included the transition to the Electricity Market Design with non-regulated pricing and introduction of bidding processes for renewables. In the meantime, more than one third of all kilowatt hours comes from renewable energies. However, the energy transition has up to now basically been an electricity transition. In particular, energy transition has not yet reached the necessary momentum in the heating, building and transport sectors. In particular, in order to also fulfil the European legal obligations set for 2030 in for energy and the climate areas, the following action areas will be key for setting the course:

1. European energy transition

The energy transition has in the meantime also become a European project. Successful European cooperation will enable the German energy transition to be successful. The Federal Government participated extensively in negotiations on the European legislation package Clean Energy for All Europeans, and will incorporate this strengthened foundation of the European energy transition into the German energy transition.

Central measure:

- Integrated National Energy and Climate Plan (NECP) In December 2018, German outlined in its draft NECP which measures it will take to reach the European energy and climate goals. After consultations, the final plan will be submitted to the European Commission at the end of 2019.

2. Better synchronization of renewable energies and grid capacities

According to the Coalition Agreement between the CDU, CSU and the SPD, targeted, efficient, grid-synchronized and increasingly market-driven expansion of renewable energy sources is a prerequisite for successful energy transition and climate protection policies. The Federal Government aims to increase the share in renewables in the energy sector – especially in the context of the challenges of better synchronisation of renewable energy sources and grid capacity – in order to reach the goal set by the coalition agreement of approximately 65% by 2030. The capacity of the power grid to absorb energy is key. Increasing expansion of renewable energy is ultimately necessary for replacing electricity produced with coal and to cover the additional demand for electricity, so that climate protection goals in transport, in buildings and in industry can be achieved. By autumn of 2019, on the basis of results of the coalition work group on acceptance issues (AG Acceptance) and recommendations of the Coal Commission and taking into account the grid expansion plan, concrete acceptance measures and conditions for finance will be decided, as well as the additional paths for expansion of renewable energies in the electricity sector by 2030, in order to achieve the goal of 65% renewable Energies set out in the Coalition Agreement.

Central measures include in particular:

- The Omnibus Energy Act and determining the renewable energy path for reaching the 65% renewables target set out in the coalition agreement
- Implementing the Action Plan Electricity Grid and the package of measures decided with the Länder at the Grid Conference, in particular the Grid Expansion Acceleration Act amendment
- Network Development Plan 2019 to 2030

3. Energy efficiency and the heating transition

Despite numerous instruments and funding programmes, reduction in energy consumption and improvement in energy efficiency have not progressed far enough to date; this was exacerbated in 2017 by low oil and gas prices on the global market. Heating makes up more than half of German final energy consumption. In order to reach the energy and climate targets, it is therefore absolutely necessary to decarbonise the heating supply (heating transition) for buildings, industry and the crafts, trades and services sector. Heating networks play a key role in this process.

Central measures include in particular:

- Energy efficiency strategy
- Buildings Energy Act; assessing the options for creating tax incentives for energy-efficient refurbishment of buildings as set forth in the Coalition Agreement
- Making progress regarding the heating transition, in particular by expanding new heat networks and modernising existing networks

4. Phase-out of coal and structural change

Another big challenge is to gradually phase out coal-fired power generation, and to manage the structural change that comes with it in the coal mining areas. The climate goals for the energy sector cannot be reached without phasing out coal. The goal is to maintain energy supply security, environmental compatibility and economic viability, and to avoid structural upheaval. The workforce and their regions are entitled to good future prospects in return for their substantial contribution to the energy transition.

Central measure:

- Evaluation and implementation of the recommendations of the Coal Commission (see box below)

5. Sustainable, affordable and climate-friendly mobility

The Federal Government wants to create sustainable, affordable and climate-friendly mobility. Important ways of enhancing low-emission mobility and reaching climate goals in the transport sector include increasing the number of electrical vehicles, expanding the charging infrastructure and increasing the share of bicycles, pedestrians and local public transport. In particular, for rapid expansion of electric mobility it will be key to create sufficient incentives for sector coupling. In particular, the results of the National Platform on the Future of Mobility should be factored in. Creating viable, sustainable mobility is the goal of the research programme Sustainable Urban Mobility. This will require continued high-level investment in the rail infrastructure, the introduction of innovative technologies in rail transport and new logistics solutions, as proposed in the final findings of the Future Alliance for Rail Transport. Ultimately, an automated and digitised rail transport system should be the outcome. Due to the increasing need for transportation, it is more important than ever to break the link between traffic volume and energy consumption. There must be stronger efforts made to find ways to avoid transportation demand or to diminish the amount of transport. A reversal of the trend in the transport sector, with significantly lower energy consumption, is and will remain a long-term project. European legislation to reduce the CO_2 emissions of road vehicles will 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.

Central measure:

- Setting up a National Platform on the Future of Mobility
- Interim report of the Working Group 1 of the National Platform on the Future of Mobility

6. Climate protection

The Federal Government is preparing a 2030 Programme of Measures for the 2050 Climate Action Plan and the National Energy and Climate Program. These measures should ensure that the reduction target for 2030 (at least 55% less compared with 1990) is reached and all sectors contribute to this target. The Coal Commission has developed recommendations for meeting the 2030 targets for the energy sector set out in the 2050 Climate Action Plan (see box below). All of the measures are evaluated with regard to their ecological, economic and social impact. As agreed in the Coalition Agreement, the German Federal Government will draft a law that should enforce compliance with the 2030 climate targets.

Central measures include in particular:

- Programme of measures 2030 for the 2050 Climate Action Plan
- Legislation to ensure compliance with the 2030 climate protection targets
- The Climate Protection Cabinet Committee, to prepare the legally binding implementation of the 2030 climate protection targets

In all of these areas the Federal Government utilizes market processes to the greatest extent possible, in order to implement the goals of the energy transition both technology-neutral and cost efficiently.

Implementation of the recommendations of the Coal Commission

After intensive debate, the 28 members of the Coal Commission agreed on a phase-out of coal-fired power generation that will provide citizens and businesses planning security and prospects for sustainable development in the era after coal. At the end of January 2019, the Coal Commission presented its final report to the German Chancellor. The Commission comprises representatives from various groups: Experts from business, environmental organizations, trade unions, citizens' initiatives and the regions affected by coal phase-out. Numerous scientists and interest groups provided input.

The final report of the Coal Commission includes a number of structural and energy policy recommendations that will lead to a gradual reduction and finally, the phase-out, of coal-fired power generation and combine it with successful structural development. The final report is available on the Website of the BMWi.

The Federal Government adopted key principles on 22 May 2019 for implementing the structural policy recommendations of the Coal Commission. This policy will provide the framework for enabling the coal regions to continue to develop into modern energy and economic regions. The key principles stipulate that the Federal Government will provide up to €40 billion by 2038 at the latest for the continued development of previous lignite mining sites in Brandenburg and Lusatia in Saxony, in North Rhine-Westphalia west of Cologne and in Saxony and Saxony-Anhalt in the area near Leipzig and Halle. The coal sites that are particularly hard hit and the former lignite mine in Helmstedt will also receive support.

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. The Federal Government publishes key data on the energy transition in regular reports. Dialogue with the commission of experts on the Energy of the Future monitoring process and the high-level energy transition platforms that focus on the electricity market, energy efficiency, buildings, energy grids and research and innovation promote exchange with representatives from the Länder, the business community, society and academia. Joint 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.

In order to achieve the greatest consistency possible and to optimize synergies, the national monitoring process should also be coordinated with governance of the European Energy Union and the National Energy and Climate Plan (NECP). It is important to ensure that both processes observe the goals relevant to each process on the national and European level, respectively, while taking the interaction between the two levels into count. In addition, the timing of the national progress reports will be aligned more closely with the progress reports of the NECP processes, which must be published every two years starting in 2023. In order to facilitate the assessment of long-term trends using a data base spanning several years, the national progress report is scheduled for publication every four years instead of every two years, starting in 2022. In any case, the national monitoring process should be retained in addition to the European governance process. This allows for an assessment of the energy transition that adequately and quickly considers issues specific to the national situation as well as including national data.

2 Objectives of the energy transition and monitoring indicators

The energy transition is gradually shifting Germany's energy sources from fossil fuels and nuclear energy to renewable energies. 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.

Part I of the Progress Report examines the quantitative targets of the energy transition. As Table 2.1 shows, these targets extend through to 2050, with some milestones set for 2020, 2030 and 2040.

Table 2.1: Quantitative targets of the energy transition and status quo (2017)

	2017	2020	2030	2040	2050
Greenhouse gas emissions					
Greenhouse gas emissions (compared with 1990)	-27.5 %	at least -40 %	at least -55 %	at least -70 %	largely greenhouse-gas-neutral -80 % to -95 %
Renewable energy					
Share of gross final energy consumption	15.9 %	18 %	30 %	45 %	60 %
Share of gross electricity consumption	36 %	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	13.4 %	14 %			
Efficiency and consumption					
Primary energy consumption (compared with 2008)	-5.5 %	-20 % →			-50 %
Final energy productivity (2008–2050)	1.0 % pro Jahr (2008–2017)	2.1 % pro Jahr (2008 – 2050)			
Gross electricity consumption (compared with 2008)	-3.3 %	-10 % →			-25 %
Primary energy consumption in buildings (compared with 2008)	-18.8 %	→			-80 %
Heat consumption in buildings (compared with 2008)	-6.9 %	-20 %			
Final energy consumption in the transport sector (compared with 2005)	6.5 %	-10 % →			-40 %

Source: In-house data from the Federal Ministry for Economic Affairs and Energy, 3/2019

* A targeted, efficient, grid-synchronized and an increasingly market-driven expansion of renewable energy sources is a prerequisite for successful energy transition and climate protection policies. The Federal Government aims to increase the share in renewables in the energy sector – especially in the context of the challenges of better synchronisation of renewable energy sources and grid capacity – in order to reach the goal set by the Coalition Agreement of approximately 65% by 2030. The capacity of the power grid to transport energy is key. Increasing expansion of renewable energy is ultimately necessary for covering the additional demand for electricity, so that climate protection goals in transport, in buildings and in industry can be achieved.

Part II of the Progress 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 2.2). 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. 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. The research project titled Definition and Monitoring of Supply Security in European Energy Markets commissioned by the Federal Ministry for Economic Affairs and Energy defines indicators and threshold values suited to measuring and assessing the security of supply in the electricity market.

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, and was amended in March 2017 to adapt it to the current situation. However, surveys for 2017 were conducted in accordance with the original Act.

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 of deviation 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.

The chapters on quantitative goals of the energy transition provide an outlook for 2020. This chapter presents updated 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 target architecture study is set up as a meta analysis and assesses the effects of instruments in the target architecture up to 2020 as compared with a reference situation. By comparing a time corridor

Table 2.2: Additional 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 Heating transition Digitisation	Unlocking the potential of efficient sector coupling, the heating transition and digitisation for a successful energy transition.
Research Innovation	Fostering forward-looking innovations for restructuring 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, 03/2019

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 under way are factored in until 2020. The breadth of the corridor reflects uncertainty regarding the effectiveness of the instruments and the basic socio-economic data. Current findings are based on the status of measure at the end of 2018. The Federal Government does not take ownership of the current results, however it does include them in its assessments of expected developments of major key indicators. For details on methodology please refer to the Sixth Energy Transition Monitoring Report.

The quantitative chapters also provide an outlook on 2030 and 2040. The results of a project on a research project accompanying the Integrated National Energy and Climate Plan (NECP) are cited. The project was initiated by the Federal Ministry for Economic Affairs and Energy and is still ongoing. Preliminary findings on trends in reference values based on the status quo of measures at the end of 2017 were incorporated in the NECP drafted by the Federal Government and published at the end of 2018. In the meantime the analytical work for the project has taken shape. The outlook for the trend for 2030 and 2040 compared with the reference situation is based on an updated reference scenario. For this reason, individual figures may diverge from those in the NECP draft. Extensive assessments of the impact of energy policy instruments based on available studies have been incorporated into the reference scenario. Overall, the reference scenario provides a complete and consistent picture of the projected development of the energy system in Germany.

The figures indicated in this Report generally reflect the data available in March 2019. 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 reporting year is the year 2017 with preliminary figures, whereby some of the data is based on more current developments.

Table 2.3: Outlook on the likely development of key indicators (2020 and 2030)

	2020		2030	
	Estimate [min-max-spread] Current Target Architecture Study	**Target**	**Projection** NECP reference scenario	**Target**
Renewable energy				
Share of gross final energy consumption	18.4% (17.9% to 18.8%)	18%	22.6%	30%
Share of gross electricity consumption	43.4% (41.3% to 45.1%)	at least 35%*	52.9%	Renewable Energy Sources Act 2017: 40–45% by 2025 by 2030: at least 50%*
Share of heat consumption	15.2% (14.9% to 16.2%)	14%	18.8%	
Effizienz und Verbrauch				
Primärenergieverbrauch (gegenüber 2008)	-10.8% (-10.3% to -11.2%)	-20%	-21.0%	
Bruttostromverbrauch (gegenüber 2008)	-4.0% (-2.5% to -5.2%)	-10%	-6.5%	
Wärmebedarf Gebäude (gegenüber 2008)	-7.7% (-6.8% to -9.0%)	-20%	-17.4%	
Endenergieverbrauch Verkehr (gegenüber 2005)	5.4% (5.0% to 5.8%)	-10%	4.0%	

Source: In-house data from the Federal Ministry for Economic Affairs and Energy, 3/2019
* Targeted, efficient, grid-synchronized and an increasingly market-driven expansion of renewable energy sources is a prerequisite for successful energy transition and climate protection policies. The Federal Government aims to increase the share in renewables in the energy sector – especially in the context of the challenges of better synchronisation of renewable energy sources and grid capacity – in order to reach the goal set by the Coalition Agreement of approximately 65% by 2030. The capacity of the power grid to transport energy is key. Increasing expansion of renewable energy is ultimately necessary for covering the additional demand for electricity, so that climate protection goals in transport, in buildings and in industry can be achieved.

With this report, the Federal Government fulfils its reporting obligations pursuant to Section 63 (1) of the Energy Industry Act, Section 98 of the Renewable Energy Sources Act and Section 24 of the Core Energy Market Data Register Ordinance and with regard to the National Action Plan on Energy Efficiency (NAPE) and the Energy Efficiency Strategy for Buildings (ESG).

3 The energy transition in the European and international context

3.1 Where do we stand?

Regarding the goals the EU 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 close or has reached these goals ahead of time in some areas. However, there is very little time left to close all of the existing gaps. For example, with regard to annual energy savings there is a great need for action.

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.

Introduced in 2005, the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) comprises emissions of around 11,000 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 40% of all GHG emissions in Europe. The goal of reducing by 2020 EU greenhouse gas emissions by 20% compared to 1990 levels, or by 14% compared to 2005, has two parts: about two-thirds of the

Table 3.1: Overview of major EU 2020 and 2030 targets

	2017	2020 targets	2030 targets (according to informal trilogue agreements)	Comments
GHG reduction (compared with 1990)	22%	at least 20%	at least 40%	binding
GHG reduction in the EU ETS area (from 2005)[1]	26%	21%	43%	binding
GHG reduction in the non-ETS area (from 2005)[1]				
• for all of the EU	10.8%[2]	10%	30%	binding
• for Germany	2.7%[2]	14%	38%	binding
Renewables percentage				
• of gross final energy consumption	17.5%	20%	at least 32%	binding
at the EU level				
in Germany	15.5%[3]	18%	no country-specific targets, rather national target amounts that must be added to the binding EU target	binding
• in the heating/cooling sector	19.5% (EU) 13.4% (Germany)		Increase of 1.1 percentage points annually (waste heat and waste cooling included: 1.3 percentage points annually)	indicative
• in the transport sector	7,6% (EU) 7,0% (Germany) (incl. duplicate figures for biofuels from waste, residues and lignocellulose)	10% (incl. duplicate figures for biofuels from waste, residues and lignocellulose)	At least 14% (incl. quadruplicate figures for electricity in road transport, 1.5 factor for rail transport, nationally determined duplicate figures for biofuels from residues and other rules) with a maximum of 7% 1st generation biofuels	no sector targets, rather commitment to introduce a certain percentage to the market
Reduction of energy consumption				
• at the EU level	9.2% reduction in primary energy consumption from 2005	by 20%[4] (= 13% drop in primary energy consumption from 2005)	by at least 32.5%[3]	Indicative for 2020, not defined for 2030
• in the individual EU Member States		indicative national contributions to reaching targets	no country-specific targets, rather national target amounts that must be added to the binding EU target	indikative
		additional cumulative final energy savings of 1.5% annually	additional real cumulative final energy savings of 0.8% annually	binding
Interconnection in EU Member States	in Germany: 9%	10%	15%[5]	indikative
Electricity trading/exchange		Make overall system more efficient and increase security of supply		

Source: BMWi 3/2019

1 See Chapter 3

2 Preliminary targets; Status in all of the EU: 02/2019; Status in Germany: 03/2019 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 According to the requirements of EU Directive 2009/28/EC

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

5 Additional thresholds make this figure more specific

reduction should come from sectors within the EU ETS, and one-third from sectors outside of the EU ETS. This equates to a goal of 21% reduction by 2020 compared with 2005 for EU ETS sectors.

Whereas the target for the EU 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. The targets for 2020 were adopted in the 2013 ESD Effort Sharing Decision.

Germany may miss its goal of reducing emissions in the non-ETS sectors by 14% by 2020. Member States are not legally bound to fulfilling their 2020 targets as of a strict and precise date. However, they must furnish proof that they have enough emissions allowances for each year from 2013 to 2020 from the Effort Sharing Decision to cover their actual emissions. Unused allowances may be transferred without restriction to later years of the allocation period or transferred to other Member States. Because Germany is expected to use up by 2020 the emissions it saved between 2013 and 2015 that were below the annual allowance, it might be forced to purchase emissions allowances from other EU Member States or emissions allowances by means of international market mechanisms.

Whereas overall global CO_2 emissions did not increase in 2015 and 2016, or hardly at all, there was a noticeable increase in 2017 of 1.2%. CO_2 emissions reached the highest level ever, at over 37 billion tonnes.

In November 2016 the European Commission introduced a draft for an extensive legislative package titled "Clean Energy for All Europeans". This package is the foundation for the European Energy Transition and creates the basis for a new European energy framework up to 2030. Central elements include the new rules for a governance system for the Energy Union (EU regulation for the Governance System of the Energy Union and Climate Protection: the 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 on individual components of the package have been concluded; the Governance Regulation and the directives for renewables, energy efficiency and buildings entered into force at the end of 2018, and the rules on the electricity market design will follow in early summer of 2019.

The integrated National Energy and Climate Plans (NECP) form the core of the Governance Regulation. Each Member State was required to submit to the European Commission by the end of 2018 a draft National Energy and Climate Plan; the final plan for 2021 to 2030 is due by the end of 2019. In their NECPs, EU Member States present their goals

and measures for carrying out their energy and climate policy for the period to 2030.

The German Federal government submitted its NECP draft to the EU Commission on time in December 2018 and then published it. This draft is based in particular on national goals of the Energy Concept and the 2050 Climate Protection Plan. The Federal Government will prepare this draft in 2019 in consultation with the public and EU neighbours, and will receive recommendations from the EU Commission that it will then address.

Key current measures taken to date in European energy policy

- Regulation on Governance of the Energy Union
- Draft for a National Energy and Climate Plan (NECP)
- Amendment of the EU Renewable Energy Directive
- Amendment of the Energy Efficiency Directive
- Amendment of the Building Efficiency Directive
- Amendment of the Regulation on the internal electricity market in the EU
- Amendment of the Directive on the internal electricity market in the EU
- Amendment of the ACER Regulation
- Risk provisioning regulation
- Initiative on "Speeding-up the Conversion of Buildings to Clean Energy"
- LIFE Programme for the Environment and Climate Action
- Revised EU energy label
- Directive on laying down ecodesign requirements for refrigerating appliances
- 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
- Programme for financing electricity and gas infrastructure
- 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

Key measures taken to date 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
- Climate Protection Regulation
- 'Europe on the Move' mobility package
- Second mobility package for regulating CO_2 emissions of passenger cars and light commercial vehicles after 2020
- Initial introduction of CO_2 emissions target for new heavy commercial vehicles
- Declaration of EU Member States on the future of clean energy and mobility
- Action Plan: Financing Sustainable Growth

The Paris Agreement 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:

- Holding the increase in global warming to well below 2°C compared with pre-industrial levels and to limit the temperature increase to 1.5°;
- Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development;
- Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The convention has been signed by 185 of the 197 contracting countries, including the EU and Germany. The convention has obligated all contracting states to prepare and submit climate protection contributions (NDCs: Nationally Determined Contributions). The Federal Government has several programs to ensure rapid presentation and implementation of the 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 yet followed the US example.

Publication in early October 2018 of the special report of the Intergovernmental Panel on Climate Change (IPCC) on possible impacts of global warming of 1.5°C brought fresh dynamics into the discussion on climate protection. The paths envisaged by the IPCC for reducing the warming trend to 1.5° involve reducing global greenhouse gas emissions by 2030 by around 45% compared with the 2010 level and reaching zero-net emissions by 2050. To reach a reduction of less than 2°C, 25% reduction would be necessary by 2030, and zero-net emissions by around 2070. If current emissions trends were maintained, an increase in temperature of 1.5°C would probably be reached in 2040s (between 2030 and 2052). According to the IPCC, the emissions level targeted for 2030 in the NDCs submitted up to now globally is not sufficient to limit global warming by significantly less than 2°C above the pre-industrial level. In order to reach the 1.5°C target, the emissions level based on the scenario calculations must be lowered by 40% to 50%.

At the 24th World Climate Conference (COP 24) in December 2018 in Katowice, uniform rules were adopted for implementing the Paris Climate Agreement. The successful negotiations were proof that it is possible to reach an agreement on binding rules at the international level. The German Federal Government worked together with other countries to reach this agreement. The international community has now basically agreed on common rules on how to fulfil the requirements of the Paris Agreement, three years after it was adopted. The goal of limiting global warming to significantly less than 2°C, if possible, to 1.5°C compared to pre-industrial levels, has thus been given a foundation of specific measures and reporting requirements The rules adopted in Katowice will provide information on how the countries' emissions are managed, details on their climate goals , and which measures will be implemented. This increases international transparency and improves the basis for planning national climate protection measures. A global update on progress will be conducted every five years. The negotiations on market mechanisms that play a key role in globally efficient climate policy are still ongoing.

3.2 What is next?

In the next few years, parts of the new EU Electricity Market Design must be transposed into national law. Whereas the Electricity Market Regulation, the Risk Provisioning Regulation and the ACER Regulation apply directly, and to a great extent as of the beginning of 2020, the Electricity Market Directive must be transposed into national law by mid-2021. Furthermore, the Electricity Market Regulation contains various requirements such as preparation of an Action Plan in order to gradually make 70% of transmission capacity available for the cross-border electricity market. The Risk Provisioning Regulation requires the Member States to develop national crisis scenarios and determine national and regionally coordinated measures to deal with such crises.

In the global context, a current analysis conducted by IRENA found that renewable energies will be able to cover up to 86% of global energy demand by 2050. At the same time, the study points out that in 2050 around one billion electrical vehicles could be on the road, and that electricity could be used increasingly for heating needs or for producing hydrogen. Hydrogen in turn could replace kerosene or oil in air or shipping travel. This could contribute significantly to fulfilling the Paris climate protection goals and provide additional impetus for economic growth and employment.

Furthermore, a study conducted by IEA and IRENA during the German G20 presidency on the prospects for the energy transition shows that achieving greenhouse gas neutrality in the worldwide energy system by 2050 is ambitious, yet technically possible and economically feasible. 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.

4 Renewable energy

4.1 Where do we stand?

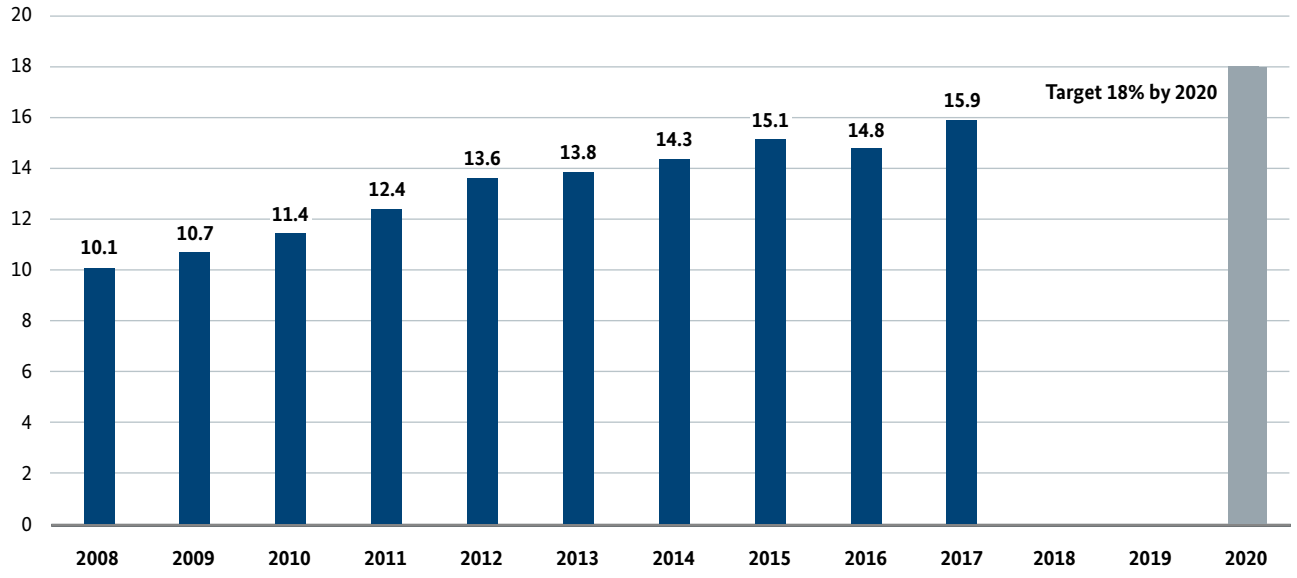
In 2017, the gross final energy provided by renewable sources amounted to 430.5 TWh, thereby covering 15.9% of total gross final energy consumption. This represents an increase over the previous year of around one percentage point. This positive trend was due mainly to the increase in energy generated by renewable energies, with a share of 36% in total gross electricity consumption in 2017. In the heating sector, the share of renewable energies in total final energy consumption for heating and cooling during the same period increased to 13.4%, and the share of renewables in total final energy consumption in the transport sector remained constant, at 5.2%.

Preliminary estimates for 2018 arrive at a share of 16.7% of renewables in total gross energy consumption, an increase of around 5% or 0.8 percentage points compared with the previous year (15.9%). This is another (large) step toward the goal of 18% for 2020.

Figure 4.1: Renewable energy and gross final energy consumption

2020 target	Renewables will cover 18% of gross final energy consumption
Status in 2017	15.9%

Share of gross final energy consumption in %



Source: AGEE-Stat 02/2019

Trend	●●●●●
Measures	Renewable Energy Sources Act, Market Incentives Programme, Renewable Energies Heat Act, greenhouse gas emissions rate, etc.

At 216.3 TWh, electricity generated from renewable sources in 2017 was significantly above the previous year (2016: 189.7 TWh). This corresponds to an increase of about 14% over the previous year. The share of renewable energies in gross energy consumption showed a significant jump from 31.6% in 2016 to 36.0% in 2017. According to preliminary figures, the share of renewables in gross energy consumption in 2018 was 37.8%. This means that the 35% target for 2020 has already been reached.

Financing for existing renewable energy plants continued to increase in 2017 and 2018. 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. After rising only slightly in previous years (from €21.9 billion in 2015 to €22.2 billion in 2016), overall financing demand went up sharply again in 2017 to about €23.4 billion. In 2018, this figure was €25.6 billion (preliminary figure).

The need to finance renewables is counteracted by 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. By using renewables, 184 million tonnes of CO_2 equivalent were avoided in 2018. In addition, the expansion of renewables produces macroeconomic benefits: for example, less use of fossil fuels causes energy imports to fall. In addition, the promotion of renewables in Germany through the Renewable Energy Sources Act and other means has also contributed at an international level to a reduction in technology costs in the field of renewable energy.

The EEG surcharge in 2019 is 6.405 ct/kWh. This means that it has gone down for two straight years, and by around 6% compared with 2018. The surcharge has ranged between 6.2 and 6.9ct/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.

Key measures taken to date for renewable energy in the electricity, heating and transport sectors

- Renewable Energy Sources Act 2017 (EEG)
- Act to Revise the EEG 2017
- Landlord-to-Tenant Electricity Act
- Omnibus Energy Act (e.g. special bidding process for onshore wind energy and photovoltaics)
- 2015 Revision of the Market Incentive Programme, including heat pump funding and expansion since 2016 with the Energy Efficiency Incentive Programme (APEE)
- harmonised regulatory system for the heating market
- low temperature heat networks with seasonal thermal energy storage
- measures regarding electric mobility/biofuels/rail transport

4.2 What is next?

Regarding the 2020 goals for the share of renewable energies in gross electricity and heating consumption, the energy transition is on track, even though the expansion of renewables was markedly slower in the electricity sector in past years (2013–2017). The 2020 goal for share of renewables in gross final consumption of energy will be just barely reached according to the Target Architecture Study – additional efforts will be necessary. This applies in particular to the increase in renewables in the energy sector targeted by the Federal Government that is necessary to achieve the goal set out in the Coalition Agreement of approximately 65% by 2030 – which was basically the target originally set for 2040.

In order to reach the 65% target by 2030, it is necessary to dedicate additional land to wind-powered installations. A key prerequisite for expanding onshore wind energy is approving space with land-use planning procedures. Currently around 1% of land in Germany is dedicated to wind energy. Wind power has already been installed on more than half of this area. As part of the repowering process, these spaces are reassessed as to whether they can continue to be used for wind energy. Those spaces not suitable for installing wind power are often lack acceptance or run into approval hurdles (requirements under conservation law, aviation or military concerns). Accordingly, the barriers to further expansion of possible areas for installation are being analysed and efforts will be made to reduce them.

There is sufficient potential for expansion of photovoltaics on roofs and ground-mounted installations. According to the 2018 Expert Report on the Renewable Energy Sources Act Progress Report, the current capacity of solar rooftop panels of about 30GW corresponds to 10% of the potential for solar energy.

Targeted, efficient, grid-synchronized and an increasingly market-driven expansion of renewable energy sources is a prerequisite for successful energy transition and climate protection policies. The Federal Government aims to increase the share in renewables in the energy sector – especially in the context of the challenges of better synchronisation of renewable energy sources and grid capacity – in order to reach the goal set by the Coalition Agreement of approximately 65% by 2030. The capacity of the power grid to transport energy is key. Increasing expansion of renewable energy is ultimately necessary for replacing electricity produced with coal and to cover the additional demand for electricity, so that climate protection goals in transport, in buildings and in industry can be achieved.

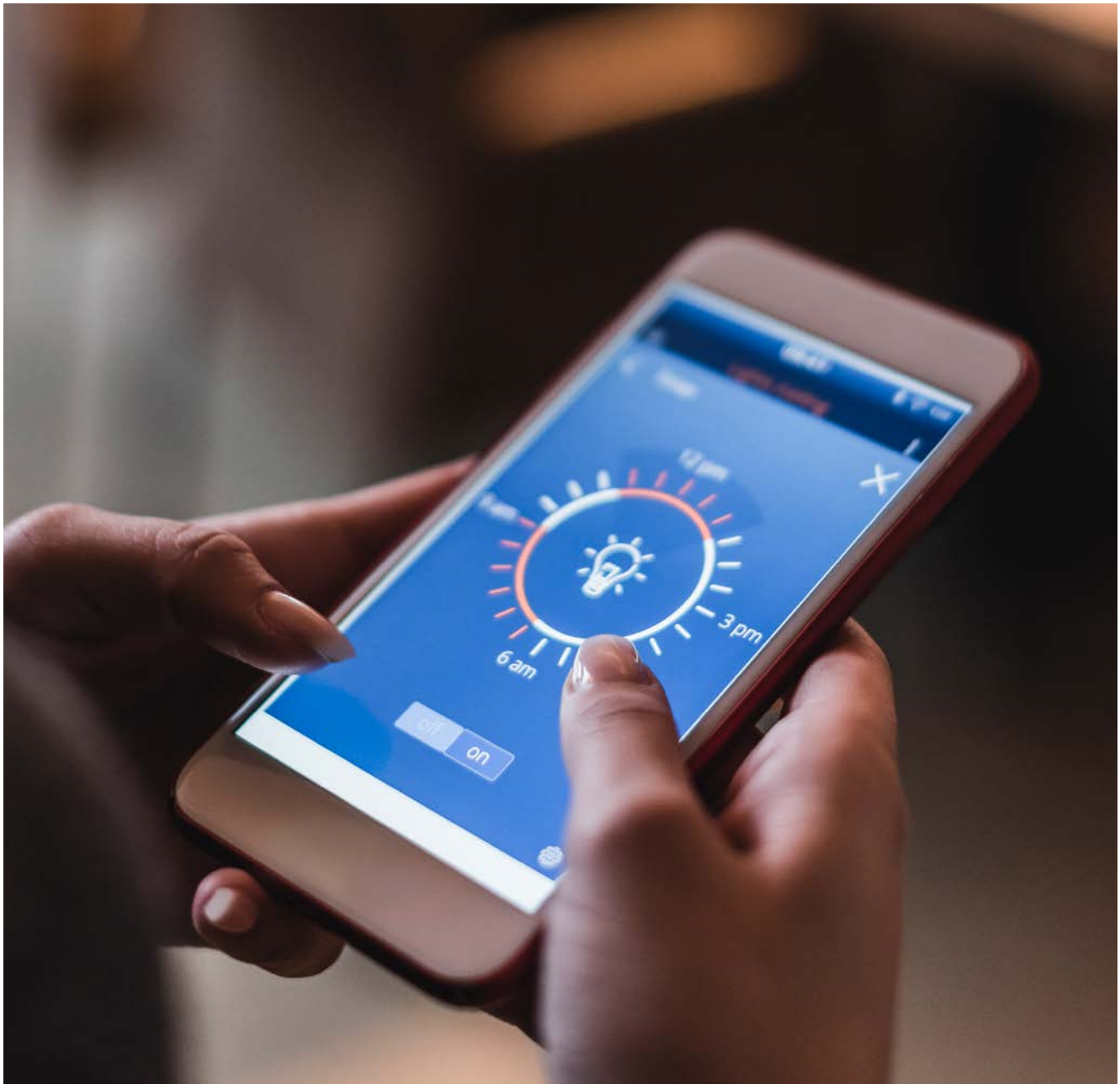
The Federal Government is continuing to prioritize the expansion of renewable energy sources. A working group was formed with members from the coalition parties for conferring on measures for increasing the acceptance of onshore wind energy. Based on the findings of this group and on those of the Coal Commission, as well as the further trend in grid expansion, a decision will be reached by autumn of 2019 on concrete acceptance measures and on funding conditions, as well as future paths of expansion of renewable energies in the electricity sector by 2030, in order to achieve the goal of a 65% share in renewable set out in the Coalition Agreement. During a three-year pilot phase (2019-2021) the Federal Government will also gain experience with cross-technology bidding invitations.

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. The German Federal Government will continue to promote the heating transition – indispensable for achieving energy and climate targets.

In order to transition the energy system almost completely to renewable energy sources by 2050, innovative techno-

logical solutions and new business models will be necessary to contribute substantially to efficiently implementing the energy transition. In addition, it is important to increase efforts to mobilize private capital. Market processes best utilize the decentralized knowledge of actors and ensure that new knowledge is discovered. This is a means of identifying the most efficient trans-technology and trans-sector solutions.

5 Energy consumption and energy efficiency



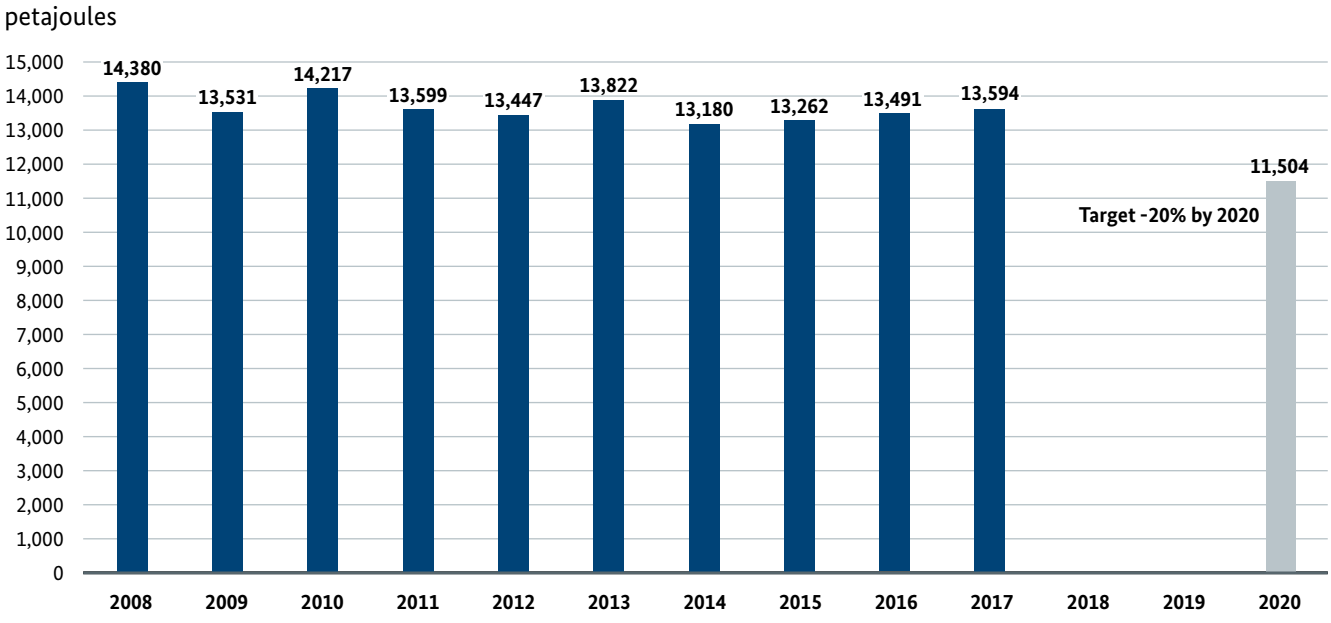
5.1 Where do we stand?

Primary energy consumption rose slightly in 2017 compared with the year before. In 2017, primary energy consumption stood at 13,594 PJ, up 0.8% on the previous year. Contributing to the increase are both strong economic growth of 2.2% as well as an increase in the population of about 308,000 persons. Following adjustments for the effects of temperature and inventories, primary energy consumption energy consumption in 2017 was 1.1% higher than the previous year. The rise in consumption due to the economy and population growth were only partially counteracted by increases in energy efficiency.

Compared with the reference year (2008), primary energy consumption in Germany had dropped by 5.5% in total in 2017. In order to reach the reduction target for primary energy consumption by 2020, this consumption would have

Figure 5.1: Reducing primary energy consumption

2020 target	20% reduction in primary energy consumption (compared with 2008)
Status in 2017	-5.5%



Source: AGEB 08/2018

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

to be further reduced by 14.5 percentage points compared with the level of 2017. In absolute numbers, this is the equivalent of around 2090 PJ, that is, the entire German annual electricity consumption. Such a decline by 2020 is unlikely.

According to preliminary figures, in 2018 primary energy consumption dropped significantly compared to the previous year, by 4.6%. This follows from the annual report of the Working Group on Energy Balances (AGEB). According to the report, energy consumption in Germany declined for the first time since 2014, and was at the lowest level since 1972. The drop in energy consumption is attributable especially to sharp increases in energy prices, the unusually mild weather and a strong rise in 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 and for non-energy related consumption. Final energy consumption reached 9,329 PJ in 2017, an increase of 2.8% over the previous year. Following adjustments for the effects of temperature and inventories, final energy consumption in 2017 rose 3.3% on the previous year. Broken down by sector, the unadjusted increase in consumption highest in industry, at 3.5%, followed by the trade, commerce and services sector at 3.4% and transport at 2.4%. Households consumed 2.2% more final energy than in the previous year.

Between 2008 and 2017, final energy productivity improved by 1.0% 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 5.6% annually in the three years between the reporting year 2017 and 2020 to achieve the pre-determined target set by the Energy Concept. This acceleration is very unlikely. However, the goal is still to produce 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.

Between 2008 and 2017, gross electricity consumption declined by around 3.3%. The goal is to reduce gross electricity consumption by 10% by 2020 (compared with 2008). In order to reach this goal, consumption would have to go down by another 6.9 percentage points – about 24 TWh – in the years between the reporting year 2017 and the target year 2020. This is more than the annual electricity output of four nuclear power plants. Here we must take into consideration 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, cooling or propulsion energy, and thereby replace the largest possible amount of fuel with a small amount of renewable electricity.

5.2 What is next?

Overall, there is a great need take action to achieve the 2020 targets for energy efficiency as quickly as possible. The progress made thus far is not enough. Regarding the 2030 targets, the NECP reference scenario indicates that additional measures must be taken to reach these goals.

The Federal Government plans to present an energy efficiency strategy in 2019. Energy efficiency is part of the foundation of the energy transition. The national energy and climate policy goals for 2020, 2030 and 2050 cannot be reached without additional efforts to enhance energy efficiency. This also applies to Germany's obligations at the European level, especially in the non-ETS area.

The efficiency strategy is slated to be adopted by the Federal Government in 2019. The essence of the strategy is to set an interim goal for primary energy for 2030. The guiding principle is to halve primary energy consumption by 2050 (compared with 2008). Emphasis will also be placed on the heating transition. The National Action Plan on Energy Efficiency (NAPE) adopted in 2014 by the Federal Government should also be further developed based on the results of the Energy Efficiency Green Paper and implemented as soon as possible. It is planned that this National Action Plan on Energy Efficiency 2.0 will contain a specific package of measures for the decade 2021–2030 with measures for the sectors and trans-sector instruments. This package of measures will then create the basis for the chapter on Energy Efficiency of the German National Energy and Climate Plan and for implementation of the 2050 Climate Protection Plan. The Energy Efficiency Platform and the Buildings Platform will ensure that all relevant actors are involved.

In order to reach the national and European energy and climate goals, Germany must press ahead with decarbonisation of the heating supply for buildings and for the industry sector and the crafts, trades and services sectors. Accordingly, the heating transition will receive more attention from policy makers. Because even greatly accelerated expansion could not make it possible to completely satisfy the demand for heating with renewable energies, the energy transition trio should be pursued in the heating sector: First of all, energy consumption for heating purposes must be drastically reduced, then direct thermal use of renewable energies must be better exploited and finally, the remaining demand satisfied with energy-efficient sector coupling. At the same time, the limits of how much biomass will be reliably available over a long period of time must be taken into account. Heating networks that allow for decarbonised heat supply are one of the key technologies, and will be the focus of work in this area. Biogas plants connected to local heating networks could make a contribution, especially in rural areas that are hard to reach.

The "Energy Efficiency and Heating with Renewable Energy" assistance program run by the Federal Ministry for Economic Affairs and Energy is still actively implemented. As in the industry sector, funding for the buildings sector will be restructured. Improved coordination of the programmes and designed them to appeal to the recipients are means of enhancing productivity.

6 Buildings

6.1 Where do we stand?

Final energy consumption in buildings, hereinafter also referred to as heating energy demand, rose in 2017. 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. Heating energy demand reached 3,214 PJ in 2017, an increase of 2.6% over the previous year. This increase was largely due to the relatively cold temperatures in January and September compared to the previous year, leading to increased heating demand.

Even though heating demand increased in each of the previous four years, it has decreased by 6.9% overall since 2008. This means that heating energy demand fell annually by around 0.8% on average during this period. To achieve a reduction of 20% by 2020 as compared with 2008, heating demand would have to go down by another 13.1 percentage points from the 2017 level. Such a decline by 2020 is unlikely.

Primary energy consumption of buildings rose by 1.9% in 2017 over 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 2017, primary energy consumption stood at 3,555 PJ compared with 3,488 PJ in the previous year.

6.2 What is next?

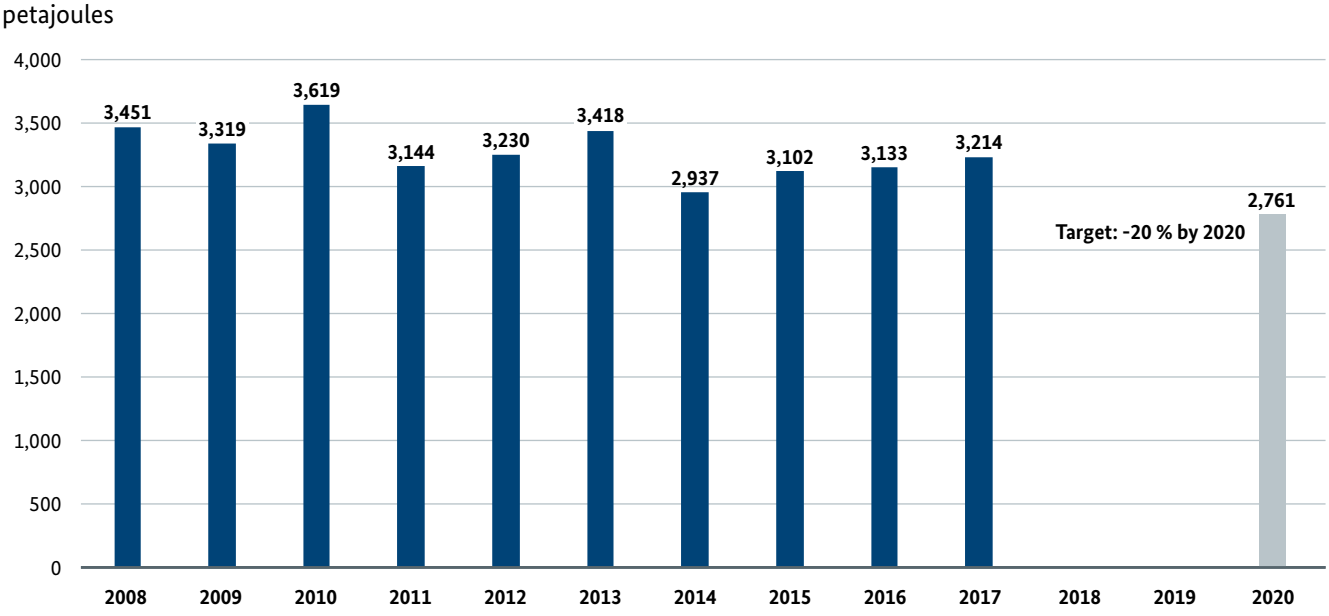
Overall, there is a great need take action to achieve the targets for the buildings sector as quickly as possible. The progress made thus far is not enough. Even so, it should be noted that even new measures would require a certain period of time to take effect. Potential for efficiency must be tapped more intently.

Implementation of the energy transition in the buildings sector will continue to play a key role in the future regarding the success of the energy transition. Even regarding German goals for the energy transition and the international climate protection goals in 2030 and 2050, the buildings sector will continue to be of utmost importance. One of the consequences of this is that efforts in the building sector must be continually intensified. Studies also show that there is still a great deal of potential for increasing energy efficiency in heat supply for buildings, for using renewable energies and for sector coupling and digitisation.

The Efficiency Strategy for Buildings (ESG) will remain the basis for the energy transition in the buildings sector. This strategy demonstrates that the goal of a virtually climate-neutral building stock by 2050 – comprised of buildings that on average correspond to today's Efficiency Houses 55 (KfW Effizienzhause 55)– can be reached by combining increases in energy efficiency with ramping up the use of renewable energies. Economic feasibility and social acceptability must be taken into account. For achieving the savings goal, this strategy determines a solution corridor comprising energy efficiency increases and the share of renewables in energy consumption – from today's perspective, implementation should take place within this corridor between 2030 and 2050. Depending on the scenario chosen, the ESG strategy projects a reduction in final energy consumption of about one-half, as well as share of renewable energies in the remaining final energy consumption of about 60% to 70% for 2050. To provide assistance for the ESG goals, the 2050 Climate Action Plan has set milestones as part of the Climate-friendly Building and Housing Strategy and determined strategic measures to be taken into consideration and to be implemented soon.

Figure 6.1: Meeting the target for heating energy demand

2020 target	20% reduction in final energy consumption for heating (compared with 2008)
Status in 2017	-6.9%



Source: AGEB 11/2018

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

The Federal Government plans to adopt an inter-sectoral energy efficiency strategy. It should contain specific measures for fulfilling the requirements set out in the Energy Concept and for achieving the German contribution to the EU energy efficiency goal for 2030. To this end, the strategy will focus on specific measures for the 2021-2030 decade (NAPE 2.0).

As set forth in the coalition agreement, the Buildings Energy Act will remove bureaucracy and simplify regulations, will implement EU legislation and provide continuity in energy requirements for old and new buildings.

The tax incentives for energy efficient refurbishment of buildings is a top priority measure that was set out in the Coalition Agreement to contribute to achieving the energy and climate policy goals in the buildings sector. They are intended to be a meaningful addition to existing funding programmes in the buildings sector. When implementing these incentives, the Federal Government evaluates several ways of setting them up, also under the aspect of budget requirements of the coalition agreement. To ensure that the tax incentives are effective, it is important to make refurbishment of existing building stock financially attractive. In addition, such incentives must be incorporated into existing frameworks. In doing so, tax consultants could be used as multipliers in order to spread the word regarding incentives for energy-efficient refurbishment.

Without any significant increase in refurbishment efforts for the existing building stock, it will not be possible to achieve the necessary reduction in energy consumption in the buildings sector by 2030. The analyses in Chapter 6.3.2 illustrate this. To encourage more refurbishment, new instruments are to be created in addition to expanding existing funding programmes. The “Climate Protection” cabinet committee created by the coalition on 19 March 2019 is tasked with preparing decisions on legally binding implementation of the Climate Protection Plan and on achieving the 2030 climate protection goals binding on Germany. The first programme of measures in the planning – that will also be incorporated into the National Energy and Climate Plan – aims to ensure that the reduction goals for 2030 (at least 55% lower than 1990) are reached and that all sectors contribute.

In addition to reducing energy consumption, decarbonisation of heating supply is absolutely necessary for reaching the energy and climate goals. For this reason, the focus will be increasingly on the heating transition and action will be taken to make more progress. In addition to creating incentives with various funding programmes for heating infrastructures that operate on renewables, additional measures and instruments are currently being evaluated or created in order to implement the heating transition in the buildings sector and other consumption sectors as well.

The integrated National Energy and Climate Plan (NECP) contains clear goals based on the Energy Efficiency Strategy for Buildings for this sector for the years 2030, 2040 and 2050. The NECP will be developed to include specific measures and will be submitted to the European Commission. It should also include a long-term refurbishment strategy. A large group of actors should be involved in working out the refurbishment strategy. In light of the necessary coordination of energy efficiency and renewables, it is advisable to also define goals for 2030 and 2040 for primary energy demand, in addition to the 2050 goal. Only primary energy demand combines technology-neutral approach with efficiency criteria and renewables, which would make it compatible with the system underpinning the Energy Efficiency Strategy for Buildings (ESG).

7 Transport

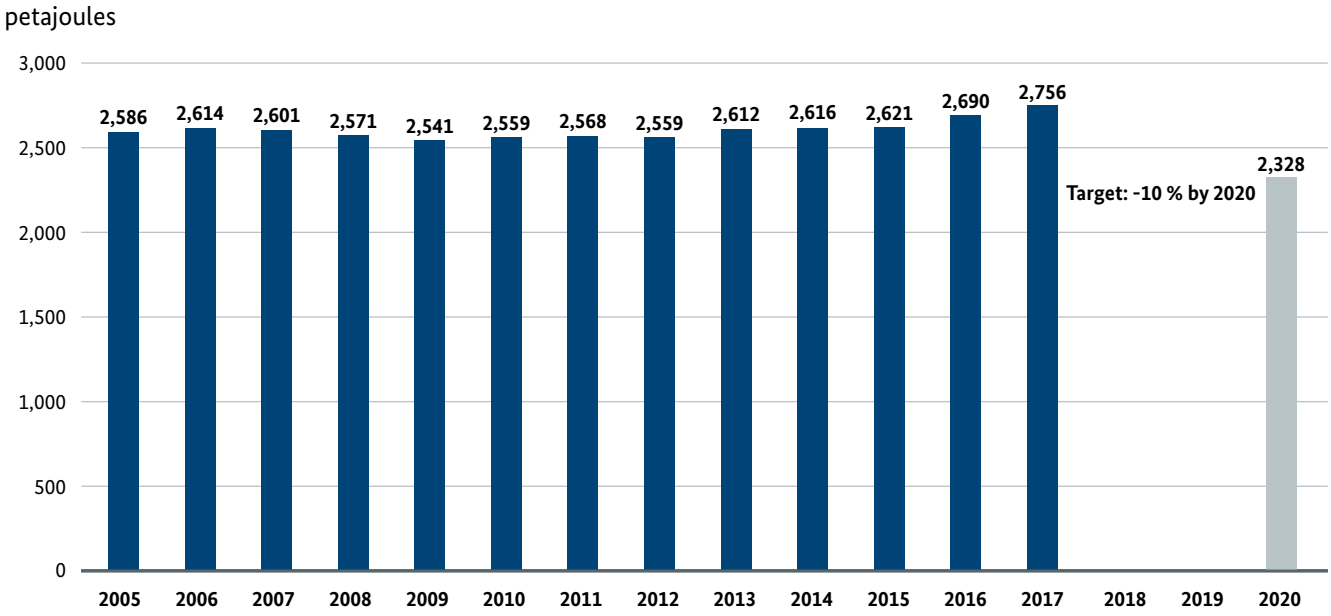
7.1 Where do we stand?

Final energy consumption in the transport sector increased in 2017. Taking all modes of transport together, final energy consumption in the transport sector stood at 2755 PJ in 2017, up 2.4% on the previous year. The transport sector therefore accounted for roughly 30% of total final energy consumption in Germany.

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 Fuel 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 designed to reduce final energy consumption in the transport sector. 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, as well as on the potential of digital solutions.

Figure 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 2017	6.5%



Source: AGEB 08/2018

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

Electric mobility already enables 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. The number of electric drive vehicles is increasing rapidly, but the market share is still small. Over 111,000 battery-powered 3-wheel-plus vehicles were registered in 2017, 44,465 of which were externally chargeable hybrid electric vehicles. However, their market share still remained at less than 2% of new 3-wheel-plus vehicle 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.

The share of biofuels is currently 4.6% of energy consumption in the transport sector. This means a savings of approximately 7.5 million tonnes of CO_2 in the transport sector.Biofuels produced with residue and waste material can also make a significantly higher contribution to reduced CO_2 emissions in mobility in the years to come.

Furthermore, hydrogen generated from renewable sources as a result of sector coupling 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 imperative in air and sea transport.

7.2 What is next?

The Federal Government wants to create sustainable, affordable and climate-friendly mobility to the greatest extent possible. Important ways of enhancing low-emission mobility and reaching consumption and climate goals in the transport sector include increasing the number of electrical vehicles, expanding the charging infrastructure and increasing the share in transportation of bicycles and pedestrians. In particular, for rapid expansion of electric mobility it will be key to create sufficient incentives for sector coupling. In addition, it will be necessary to also develop and enhance renewable, alternative fuels in conjunction with innovate drive technologies, especially in air and sea transport. Both fuel options still offer sufficient potential for volumes as well as for efficiency gains and cost cutting in production. As the potential of biomass is limited, after 2030 a large part of these fuels might be produced on the basis of electrical energy from renewable sources. The results of the National Platform on the Future of Mobility should be factored in. Creating viable, sustainable mobility is the goal of the research programme Sus-

tainable Urban Mobility. This programme focusses on systemic approaches that assess the opportunities for new technologies in the mobility sector with respect to local mobility needs. This will require continued high-level investment in the rail infrastructure, the introduction of innovative technologies in rail transport and new logistics solutions, as proposed in the final findings of the Future Alliance for Rail Transport. Ultimately, an automated and digitised rail transport system should be the outcome.

Due to the increasing need for transportation, it is more important than ever to break the link between traffic volume and energy consumption. There must be stronger efforts made to find ways to avoid transportation demand or to diminish the amount of transport. 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. These approaches will be incorporated in the decision-making process in the Climate Committee. The goal is, among other things, to use the recommendations of the National Platform on the Future of Mobility to confer on and submit by the end of 2019 a package of measures that can be used by the transport sector to meet the energy and climate protection targets of the Federal Government by 2030.

8 Greenhouse gas emissions

8.1 Where do we stand?

Total greenhouse gas emissions have gone down by 27.5% between 1990 and the beginning of 2017, according to the Federal Environment Agency (UBA). In 2017, approximately 907 million tonnes of greenhouse gas (CO_2 equivalent) were emitted. The decrease over 2016 was around 4.4 million tonnes, or 0.5%. Greenhouse gas emissions in Germany are about one-fifth of the annual greenhouse gas emissions of the European Union.

According to the most recent projection of the UBA for 2018, annual greenhouse gas emissions have gone down by around 30.8% since 1990. This reduction in emissions is due to unusual weather, but probably also to the marked growth in renewable energies and the significant drop in emissions from black coal.

Of total emissions in 2017, the largest portion was attributable to the energy sector, at almost 36%. The second largest source of emissions was industry, at around 22%, followed

by the transport sector with over 18% and the buildings sector at around 14%. Agriculture contributed around 8% to total emissions. The remaining more than 1% were produced by waste and waste water. In 2018, there were no major shifts compared to 2017 in share of emissions of the various sectors, according to current estimates.

Emissions in the energy industry in 2017 were around 19 million tonnes, a significant drop compared with 2016. This was attributable especially to the high wind power generation and the sharp drop in energy generated by coal-fired plants. This trend continued in 2018. According to current projections of the Federal Environment Agency, emissions went down by another 14 million tonnes to 311 million tonnes.

Replacing fossil fuels with renewables is a key factor in reaching climate goals. CO_2 equivalent emissions were reduced in 2017 by around 178 million tonnes. The electricity supply sector accounted for emissions of 135 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 7 million tonnes. According to preliminary figures, in 2018 approximately 184 million tonnes of CO_2 equivalent were prevented by using renewable energies.

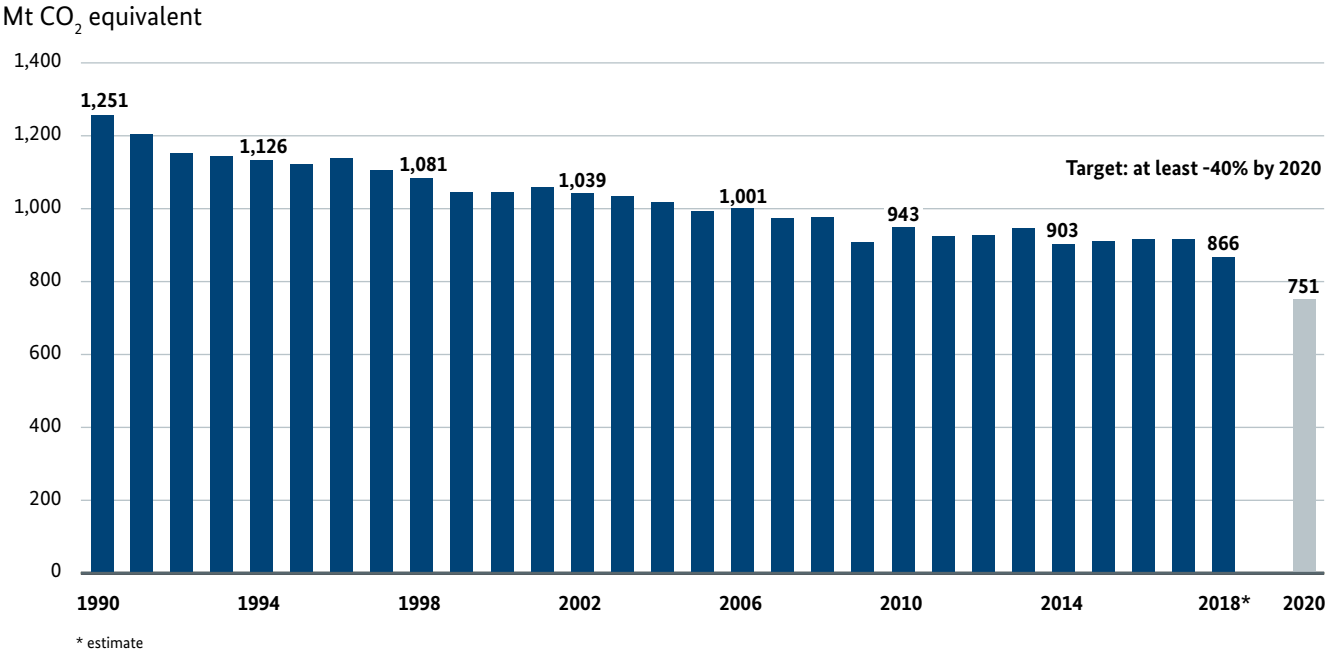
8.2 What is next?

The 2050 Climate Action Plan created in November 2016 by the Federal Government addresses the results of the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change and as a modernisation strategy is implemented on three levels: The Climate Action Plan develops specific key concepts for the individual areas requiring action for 2050, leaving room for innovation and focussing as much as possible on 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 with sector goals, also taking impact and cost analyses into account.

For the period after 2020, the 2050 Climate Action Plan is a national long-term strategy that provides important orientation and sets specific goals for the individual emissions sectors for the period up to 2030. Both the 2020 Action Programme and the 2050 Climate Action Plan follow the guiding principle of climate protection as a social and economic modernisation strategy that has a sound scientific basis, is technology neutral and efficient.

Figure 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 2017	-27.5% (preliminary figure for 2018: -30.8%)



Source: UBA 04/2019

Trend	●●●○○
Measures	2020 Climate Protection Action Programme

The 2050 Climate Action Plan embodies the government's goal of a basically greenhouse gas-neutral system by 2050 (80%-95% reduction). Now that it is clear that the national goal of 40% reduction in emissions between 1990 and 2020 cannot be reached, it is important to achieve a more comprehensive reduction in emissions in Germany. For example, sticking to the play book for phasing out coal-fired power generation would make it feasible to significantly reduce emissions in the energy sector.

At the European level, the Federal Government has set itself a goal of reducing emissions by 2030 by the national reduction target for 2030 (at least 55% less than in 1990). Expanding the use of renewable energies and focussing efforts on energy efficiency in the demand sectors are crucial steps in reaching this goal. Experience with the goal for 2020 has shown that these goals must be strictly adhered to. In particular, the German Federal Government could be faced with the cost of purchasing emissions allowances in the event that it does not meet its national obligations under the EU Climate Action Regulation (Effort Sharing Regulation).

Climate protection is and will remain a major building block for maintaining the basis for human subsistence on the earth. Limiting the climate change caused by humans and adapting to changes that can no longer be reversed are social tasks of the highest priority. Taking no action at all would cause much suffering, immense damage and irretrievable loss of habitat.

At the same time, climate protection measures can provide important impetus for enhancing Germany's economic innovativeness. Ambitious climate protection programmes not only provide an important contribution to generational justice, but also contribute to ensuring the future of our economy.

The Federal Government is working on a 2030 Programme of Measures for the 2050 Climate Action Plan that will also be incorporated in the National Energy and Climate Plan. These measures focus on ensuring that the reduction goal for 2030 (at least 55% less compared with 1990) is reached with contributions from all sectors. The Coal Commission has developed recommendations for meeting the 2030 targets for the energy sector set out in the 2050 Climate Action Plan. As agreed in the Climate Action plan, all of the measures are evaluated with regard to their ecological, economic and social impact. As agreed in the Coalition Agreement, the German Federal Government will draft a law that should enforce the compliance with the 2030 climate targets.

The Cabinet resolved on 20 March 2019 to set up a Climate Protection Cabinet Committee to ensure the legally binding implementation of the Climate Action Plan as well as of the climate protection targets for 2030 binding on Germany. The Chancellor is Chairperson and the Federal Minister of Finance in his function as Vice-chancellor is the deputy Chairman of the committee. The Federal Minister for the Environment has been named Acting Chairman. The other permanent members include the Federal Minister of the Interior, Building and Community, the Federal Minister for Economic Affairs and Energy, the Federal Ministry of Food and Agriculture, the Federal Minister of Transport and Digital Infrastructure, the Head of the Federal Chancellery and the Head of the Press and Information Office of the Federal Government. One goal of the Cabinet is to create a legally binding framework for implementing the 2050 Climate Action Plan.

9 Power plants and security of supply

9.1 Where do we stand?

Installed renewable capacity showed strong growth again in 2017. Overall, the net nominal capacity of power generation installations connected to the German grid increased by roughly 73 GW in total between 2008 and 2017. In 2017, the nominal capacity of electricity generation plants based on renewable energy amounted to 113 GW, up 8% on the previous year. The largest growth came from wind power, but solar energy and biomass also showed growth. The share of nominal capacity from renewables increased in 2017 to over 52% of total power plant capacity.

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. The Combined Heat and Power Act envisions expanding

power generation to 110 TWh in 2020 and 120 TWh in 2025. Cogeneration of heat and electricity was already at 117 TWh in 2017, a share of 19% of German electricity generation.

Germany is among the countries worldwide with the lowest down-times for electricity supply, despite a growing share of renewable energies. A reliable electricity supply is important both for Germany as a location for industry and for each citizen. In managing the energy transition, the Federal Ministry for Economic Affairs and Energy puts great emphasis on ensuring that the energy supply will remain at the highest level possible.

Currently, there are considerable overcapacities in the German and European electricity system. Overcapacity throughout Europe is around 80 to 90 gigawatts. For this reason, it was hardly advisable in the past few years to invest in a new power plant. In the meantime, however, prices are changing in the electricity market. Gas-fired power plants that had not been in operation are again producing electricity and placing it on the market. It is noticeable how market participants react quickly to shortages in power generation capacities.

Germany is completely integrated into the European power supply. All power grids in Europe are connected. Cross-border trade in electricity leads to a more efficient and cost effective use of the European power plant fleet, and enables the use of interregional smoothing effects when wind and sun power generation fluctuate. Just as it is much too expensive and complicated for each household to supply its own electricity every hour, this is true for Germany as a whole. For this reason, Germany exchanges electricity with its neighbours, so that in the end all power customers can satisfy their demand more cost-efficiently and reliably.

The Electricity Market Act of 2016 provides for continual monitoring of the security of the energy supply. The market-based design of the electricity market can ensure the most cost-efficient security of supply. Nevertheless, the energy transition is a very dynamic and fundamental transformation process for the entire energy sector. Accordingly, this development could take an unexpected turn. Ongoing monitoring will detect any problems early on and if necessary, provide counteracting measures.

Monitoring factors in all unforeseen events and developments in the electricity market that market participants could not have expected. For example, varying weather conditions are considered, including what is called the cold Dunkelflaute (dark doldrums), during which there is very little wind and solar power. The recommendation of the Coal Commission for reducing coal-fired power generation was also examined. In all of the scenarios looked at, power demand in Germany can be satisfied at all times. Analyses show that there are currently no blatant risks that require action.

There are ample reserves that provide additional supply security in the electricity market. The German Federal Government evaluates all aspects of supply security ongoing and prospectively, in order to be in a position to identify necessary measures early on and to implement them. If measures are shown to be necessary, for example to assist in the phase-out of nuclear energy and coal, they are implemented without delay.

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 take measures to ensure system stability. The duration of power interruption at the distribution grid level has remained at a consistently low level, even under international standards.

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

- Electricity Market Act
- Amendment to the Electricity Network Access Ordinance (StromNZV)
- Security standby
- Omnibus Energy Act
- Combined Heat and Power Act
- Spare capacity
- 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
- Act amending the Gas Supply Security Regulation (EU) 2017/1938SMARD
- Core energy market data register

9.2 What is next?

The final report of the Commission on Growth, Structural Change and Employment (Coal Commission) recommends a transformation of the energy plant sector. The Federal Government is currently reviewing the measures it recommended and will present a cohesive global approach. This will create the framework for the transformation of the power plant sector. The Federal Cabinet adopted key prin-

ciples on 22 May 2019 for implementing the structural policy recommendations of the Coal Commission.

The Electricity market 2.0 provides incentives for maintaining existing or constructing new power plants, storage facilities or using demand side management. Implementation of the Clean energy for all Europeans package is strengthening the Electricity market 2.0 and anchoring it in the European context. As a result, the Electricity market 2.0 is capable of satisfying power plant and storage demand at the lowest possible cost to consumers.

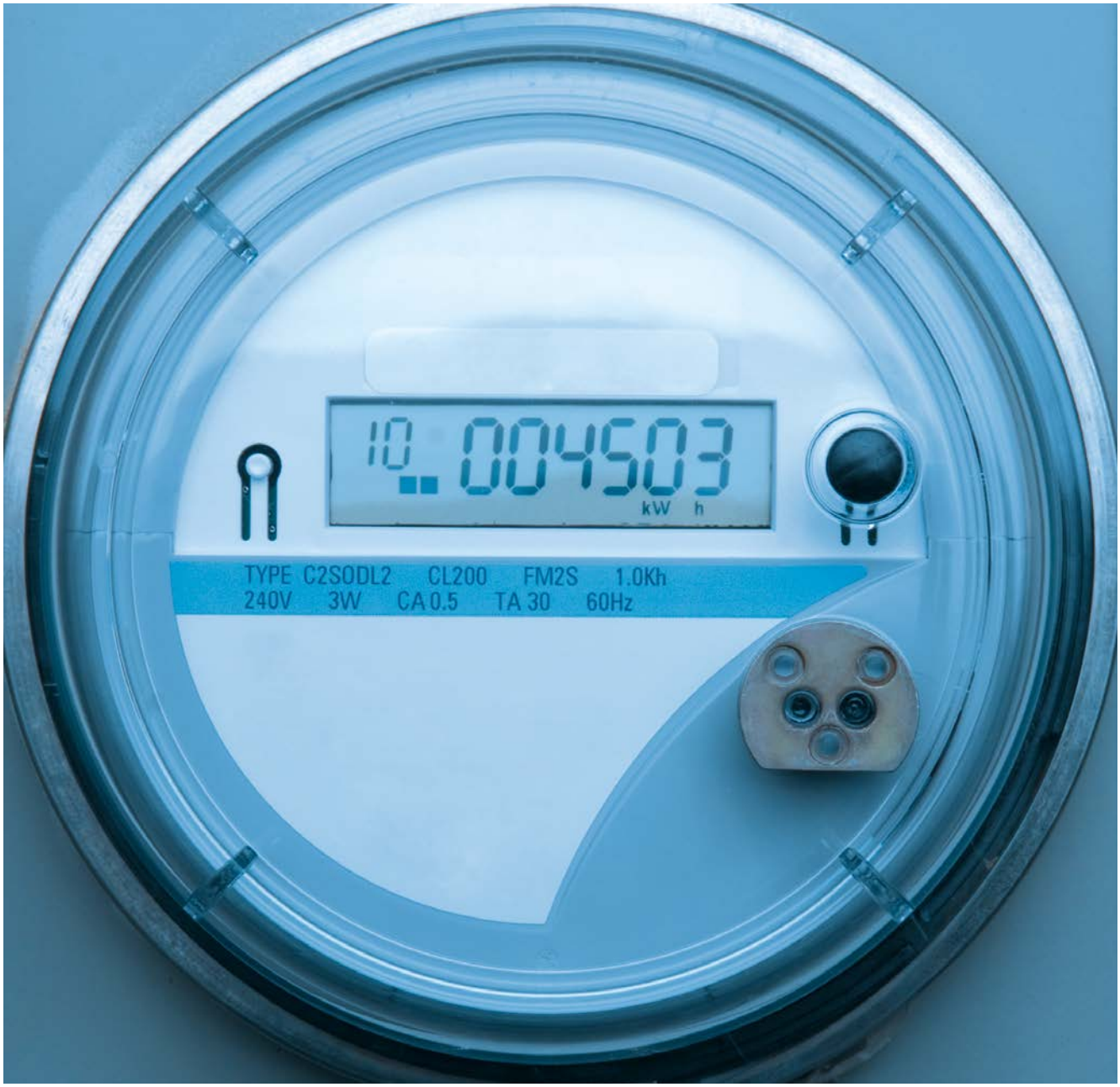
Monitoring of supply security of the electricity market shows that it will be possible to provide high quality, stable power supply in coming years. The Federal Ministry for Economic Affairs and Energy conducts an ongoing and proactive assessment of energy supply security, as stipulated in the Energy Industry Act (Sections 51 and 63 of the Energy Industry Act). Monitoring looks at varying weather conditions, including what is called the cold Dunkelflaute (dark doldrums), during which there is very little wind and solar power. The recommendation of the Coal Commission for reducing coal-fired power generation was also examined. In all of the scenarios looked at, power demand in Germany can be satisfied at all times.

The electricity supply is backed up in several ways. In addition to reserves of approximately 6 GW for covering the risk of insufficient transport capacity of transmission systems (grid reserve) and reserves of 1.2 GW for grid security (special grid technological operating means), an additional capacity reserve will be provided as of October 2020 for covering electricity demand for short-term extreme situations. This reserve comprising 2 GW will also be provided only outside of the market, and only if the market cannot cover demand even after intraday trade and using balancing capacity (including corresponding high penalty payments for those market participants that were not able to provide enough energy).

Combined electricity/heat production is not only about achieving greater expansion but also making sure that it is compatible with the future energy system. The greater the portion of renewable energies in electricity and heating grids, the more important it is that CHP is compatible with the expansion of renewables in these grids. CHP plants need to be designed for lower carbon emissions and more flexibility so that they can remain viable in the context of the energy transition. To this end the Economic Affairs Ministry is currently holding a discussion on the future of CHP with relevant actors in order to clarify what the future role of CHP will be in the energy transition and to determine what changes to the framework are necessary. Involved in this process are the results of the evaluation of the Combined Heat and Power Act mandated by law. The preliminary evaluation results and the discussion process point out that to reach the sector goals for 2030, CHP funding must be reformed (Act amending the CHP Act), beyond simply extending the period of validity. The Coal Commission has also submitted recommendations on how transform CHP plans into modern, flexible electricity/heat generation systems. In addition, the Commission recommends continuing to develop and fund cogeneration of heat and electricity by extending the CHP Act to 2030 (in 2023).

In addition, there is the option of stepping up the supply of renewable energies and waste heat to district heating formerly operating on coal, and also to modern, flexible gas-CHP systems. To tap this potential for 'green district heating', in addition to the aforementioned amendments to the CHP Act other changes in the regulatory framework are necessary, especially for funding for new heat networks or adapting existing heat networks to new standards (e.g. temperature reduction). The Federal Government is currently working on a programme of measures to enhance the instruments available for the heating transition and to ensure that the 2030 sector goals are reached. Within this framework, the Federal Ministry for Economic Affairs and Energy is planning a dialogue on "Heat networks in the context of the heating transition" to involve the Länder, associations and other relevant stakeholders. The goal is to create a mix of instruments not only for pushing forward the transformation of the heat networks, but also for contributing overall to the overall economic and social acceptance of increased decarbonisation of the heating supply.

10 Affordable energy and a level playing field



10.1 Where do we stand?

Final consumer expenditures for final energy consumption increased in 2017 from €210 billion to €218 billion, as indicated by the calculations on the basis of the Energy Balance. Because the hike in final energy consumption was accompanied by growth in the gross domestic product of 2.2%, the share of final energy expenditures in the nominal GDP was unchanged over the past year, at 6.7%.

Final consumer expenditures for electricity went up by 1.2% in 2017, from €74.1 billion to €75.0 billion. This is attributable to the increase in costs due to government-induced and regulated electricity price components, including the EEG surcharge. Overall, after a marked increase in 2013, final consumer expenditures for electricity have remained stable in the past few years. If necessary, analyses of final consumer expenditures can be broadened and refined in the future.

Compared with GDP, the share of expenditures for electricity went down again in 2017, by around 3.0%. This was the lowest level since 2010. In 2017, the share of nominal GDP comprising final consumer expenditures for electricity was at 2.3%, compared to 2.4% in 2016.

Private households spent more on energy in 2017 than in the previous year. On average, energy expenditures were about €2,782 per household, an increase of 4.1% over the prior year. Higher expenditures for fuels were a major factor, at an increase of 7.1%. Households spent 1.7% more on average in 2017 for lighting and process heat, for example for cooking. Heating costs were 2.6% higher.

Electricity prices hardly changed in 2017. On the reference date in April 2017, households paid 29.86 ct/kWh on average compared with 29.80 ct/kWh the year before, a slight increase of 0.2% over the previous year. The price components for procurement and supply dropped significantly once again. However, the EEG surcharge went up in 2017 from 6.35 to 6.88 ct/kWh. Grid charges also went up, from 6.79 to 7.31 ct/kWh. In 2018 the average electricity price was again stable in 2018, and at the reporting date was 29.88 ct/kWh. This trend was helped by the fact that the EEG surcharge in 2018 dropped slightly by 1.3%, to 6.79 ct/kWh. Because grid charges also went down, the increase in procurement prices was compensated.

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 led to very significant cost reductions in support for further development of renewables, as shown by the results of the first bidding competitions for photovoltaics and wind. Further trends will depend on the level of competition and the availability of space. 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 suppliers of end user electricity, customers can also save money by changing their supplier.

German industry spent 2.5% more on energy in 2017 than 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 €35.2 billion on energy in 2017. This increase in expenditures was attributable in particular to greater energy consumption, due in turn to positive economic growth. The biggest portion of costs for industry is electricity. Industry paid somewhat less on average for electricity in 2017, according to official figures, but consumption went up. As a result, this led to an increase in expenditures of 1.8% over the previous year. Additional cost components of industry are expenditures for gases as well as for coal products and solid fuels. The rise in expenditures for gases is also attributable to an increase in consumption, with slightly lower prices. However, coal products and solid fuels showed increases in prices and consumption, leading to an increase in these costs of 1.8%.

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. Therefore they 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.

Regulations preventing carbon leakage help reconcile the competitiveness of German industry with climate change mitigation requirements. It is already a fact that the German economy produces more but has less greenhouse gas emissions. For businesses whose products face strong inter-

national 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.

10.2 What is next?

In determining how to set the course in the energy sector, affordability and competitiveness remain a central guiding principle, in addition to environmental acceptability and security of supply. For example, it is important that measures for implementing the phase-out of coal-fired power generation as recommended by the Coal Commission take the trends in electricity prices into account. The Coal Commission has made its own recommendations to this effect. It considers it necessary to find a way to balance out the costs, to ease the burden on companies and households of possible price increases. After power plant shutdowns begin, a subsidy should be paid on the transmission grid charges or an equivalent measure that mitigates the rise in electricity prices. In addition, the Coal Commission recommends that companies that do not profit from lower grid charges be supported with additional measures. The existing compensation for parts of the electricity price attributable to the EU emission allowance trade should be enforced and further developed.

In other areas, too, such as the further development of EU state aid rules, the affordability of energy plays a central role for the Federal Government. Cost efficiency is a major criteria of the energy transition. In this vein, success stories such as the improved competitiveness achieved with the switch to bidding competition for the Renewable Energy Sources Act and the Combined Heat and Power Act have had the effect that the share of taxes, fees and charges has gone down continually since 2017. These success stories should be continued.

Transparency of affordability of energy is getting better. To this end, monitoring of energy expenditures should be further expanded so that at the end of the day the overview of expenditures is even more reliable. In particular, there are plans to extend the tracking of final consumer expenditures for electricity to the heat and transport sectors.

11 Environmental compatibility of the energy supply system

11.1 Where do we stand?

Today energy transformation processes are 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. These pollutants are not only harmful to the environment but also have an adverse effect on human health. Emissions in the air also have a detrimental effect on surface water.

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 entire energy sector, at 50%. Coal-fired plant mercury emissions are at over 75%, nitrogen oxide emissions at 16% and particulate matter at over 9% of total energy sector emissions. Even though energy-related emissions have gone down overall since 1990, this shows that the share of “classic” air pollutants is still significant.

However, biomass also creates additional emissions of air pollutants and puts a strain on soil and water. Biomass is used as renewable energy in the transport sector and for generating electricity and heat, and when combusted in relatively small and decentralised facilities, nitrogen oxides and particulate matter are released. It is also noticeable that with the use of plant-based biomass for biogas plants, ammonia emissions have increased, causing acidification, eutrophication and creating secondary particulate matter. For this reason it is important to evaluate new and previous energy conversion systems in their broader context.

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, cooling thermal power plants also disturbs the ecosystem of rivers in their material and thermal structure.

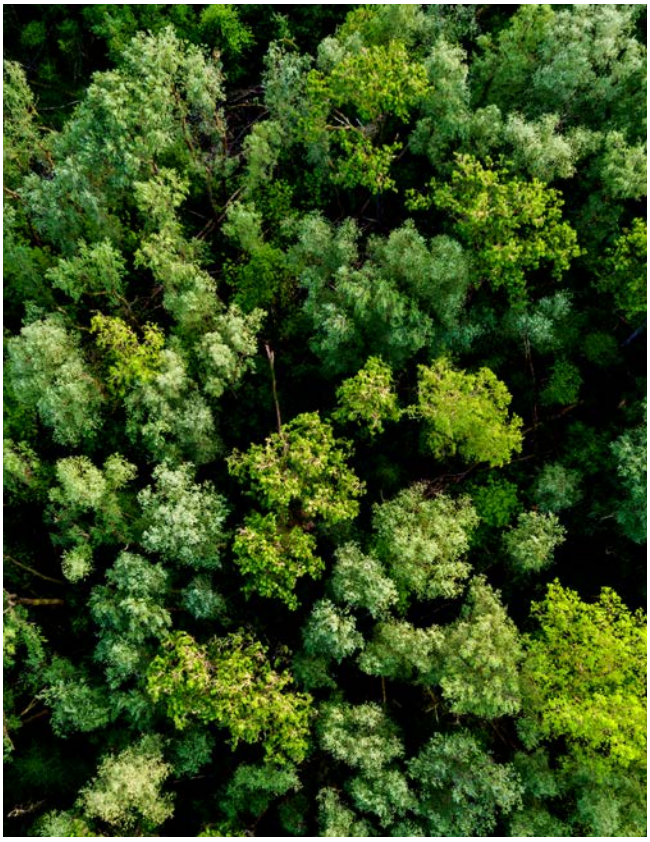
The demand for natural resources and where energy plants are located are factors for any type of energy conversion – due both to climate change mitigation and environmental considerations and to economic efficiency. By means of efficient use of natural resources and sustainable utilization of land the energy transition can provide an exemplary contribution to climate protection and at the same time, demand in Germany for primary natural resources can be substantially reduced by 2050.

In order to minimise the amount of land used for extraction, processing and transporting energy sources and energy facilities, including upstream value chains, and to avoid the permanent deterioration of soils and the loss of agricultural land, environmental monitoring should take the following facts into account: For one, the land 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 or changes the use of those spaces. In order to reduce the competition between this type of use of space for such purposes and for food production, using bioenergy from residue and waste material can have a positive impact. However, developing efficient strategies for upstream use of biogenic resources is important in this process. In conventional generation, future changes in land use should be considered, for example in the case of lignite excavation sites that are replanted, to facilitate subsequent use, even if such use is diminished compared to the original condition of the land.

Efficient generation of electricity and heating, low-loss distribution of renewable energies and reduced and flexible energy demand can decisively contribute to reducing competition for space and stress on the landscape. Technologies that are also helpful in reducing land consumption are especially 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.

Whenever efforts are made to protect biodiversity and basic resources for flora, fauna 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. Gradually reducing coal-fired power generation and increasing the use of renewable energies result in more environmentally friendly power generation.

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 using up space, loss of biotopes, 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 addition to national requirements, there are binding EU regulations that must be adhered to. Beneficial to this process is that the amendment of the Grid Expan-



sion Acceleration Act of April 2019 facilitates more prospective planning. This can lead to a reduction in stress for some parts of the environment.

Energy sector emissions mentioned in the foregoing also affect human health. For example, nitrogen oxide (NO_2) is a by-product 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. 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. Traffic, a major component of the energy system, is one of the major producers of noise.

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.

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 should help minimise over long periods of time the radioactive after-effects of the use of nuclear energy. Negative 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

- German Resource Efficiency Programme II (ProsRess II): The German Resource Efficiency Programme has been extended and expanded by 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.
- Environmental monitoring of the growth of renewable energy in the area of electricity: Research commissioned by the Federal Agency for Nature Conservation (BfN) 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:
- In February 2017 statutory rules on fracking entered into force

11.2 What is next?

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 gas or air pollution – are not yet available for assessing the environmental compatibility of the energy system. For this reason, the Federal Environment Agency commissioned a study in order to close this data gap. The results of other ongoing research projects carried out for the Federal Environmental Agency and the Federal Agency for Nature Conservation are taken into account.

12 Grid infrastructure

12.1 Where do we stand?

Of the plans set out in the Power Grid Expansion Act (EnLAG), about 45% of the entire length had been completed at the end of the first quarter of 2019. This corresponds to about 800 power line kilometres. Around 1,200 had been approved–approximately two-thirds of the project. Transmission system operators estimate completion of almost 70% of the total length under the Act by 2020. 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 North-east Germany to Southern Germany.

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 converted to 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. The Act on the Digitisation of the Energy Transition should also assist in this process.

The expansion of the power grids requires greater investment. Grid operator investments in German power grids and expenditures on maintenance dropped to a total of €9.7 billion in 2017. However, they were still far above the average of the period 2008-2017. Most of the investment in the transmission grid – about €2.7 billion – went to new grid construction and grid reinforcements. Further to this, €388 million were spent on grid maintenance and repair. At the distribution grid level, grid operators invested around €3.5 billion in the expansion and €3.1 billion in the maintenance and repair of the infrastructure.

Major measures for the grid infrastructure

- Network Charges Modernisation Act (NEMoG)
- Ad-hoc grid measures in the Network Development Plan
- Amendment to the Grid Expansion Acceleration Act
- Optimisation of network shortage management
- introduction of strategic controlling for grid expansion
- Electricity Market Act
- Act on the Digitisation of the Energy Transition

12.2 What is next?

The scenario framework for the Network Development Plan provides an outlook on the complicated energy landscape in the target year 2030. In June 2018 the Federal Network Agency approved of the scenario framework for the Network Development Plan 2019–2030, taking into account the breadth of probable developments relating to the energy policy goals of the Federal Government for the period to 2030. The scenarios factor in the goal set out in the coalition agreement of about 65% share of renewables in the electricity sector, as well as the goals of the 2050 Climate Action Plan. This will be achieved by 2030 in the individual scenarios with variations in the renewables mix (offshore wind: 17-20 GW, onshore wind: 74-86 GW; photovoltaics 73-105 GW). The 2030 climate goal will accordingly be achieved in all scenarios. The assumptions for installed coal capacity in Scenario C 2030 correspond almost exactly with the recommendations of the Coal Commission (17 GW). Accordingly, grid planning also factors in the phasing out of coal. To reflect a larger scheme of probable developments, the scenarios include assumptions on various intensities of sector coupling (e.g. number of electric cars and heat pumps, power-to-gas) and thereby also regarding various amounts of electricity consumption.

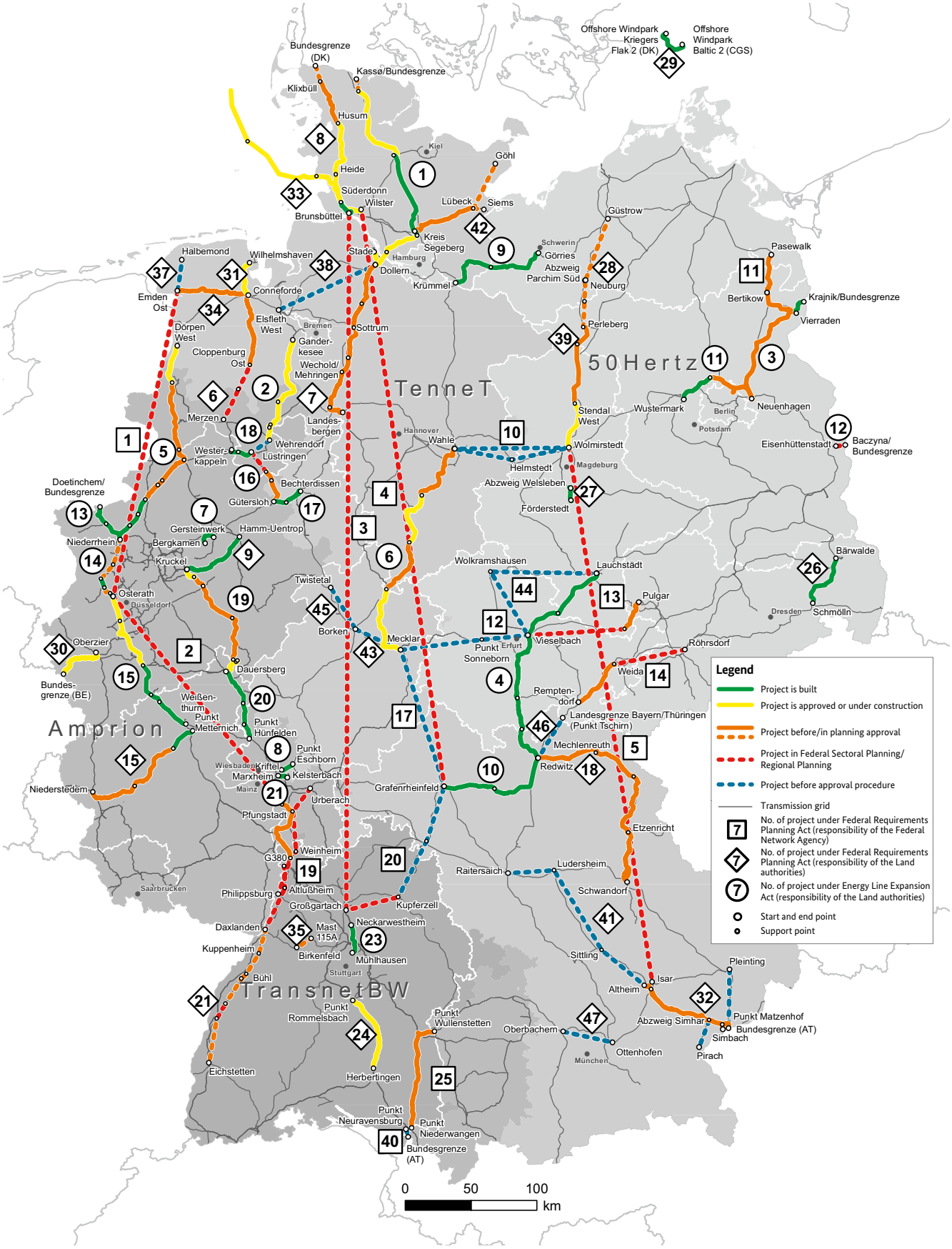
The potential grid demand is identified in the Network Development Plan. The goal of the NDP 2019-2030 is to identify the demand for grid expansion. In April 2019 transmission system operators submitted a second draft of the NDP describing future grid expansion needs. The transmission system operators project in all scenarios for 2030 – beyond the projects under the Power Grid Expansion Act and the Federal Requirements Plan Act – the need for a new HVDC corridor from the North Sea coast to North Rhine-Westphalia, and from there on to Baden-Württemberg. They also see additional need for three-phase current expansion (reinforcing existing power lines, including installation and upgrade to high current cables as well as new construction). The Federal Network Agency will use this as a base for its draft and will consult with the public in the summer. The Federal Network Agency will also factor in the recommendations of the Coal Commission on the phasing out of coal. They recommend that coal capacity in 2030 should be limited to 17 GW and a complete phase out be finished by 2038. At the end of 2019, the Federal Network Agency is expected to approve of the final NDP 2019–2030.

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.

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.

Progress in the approval process is important for rapid expansion of the power grid. The energy ministers at the Federal and Länder levels confirmed at the Grid Summit in September 2018 that they want to jointly push ahead with grid expansion programmes. They agreed that by the end of 2021:

Figure 12.1: Projects under the Energy Line Expansion Act and the Federal Requirements Planning Act



Source: Federal Network Agency Q1/2019
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 31/03/2019. 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.

- all projects under the Power Grid Expansion Act,
- all large direct current electricity motorways from north to south,
- half of all other alternating current projects managed by the Länder and
- half of all other alternating current programs managed by the Federal Network Agency

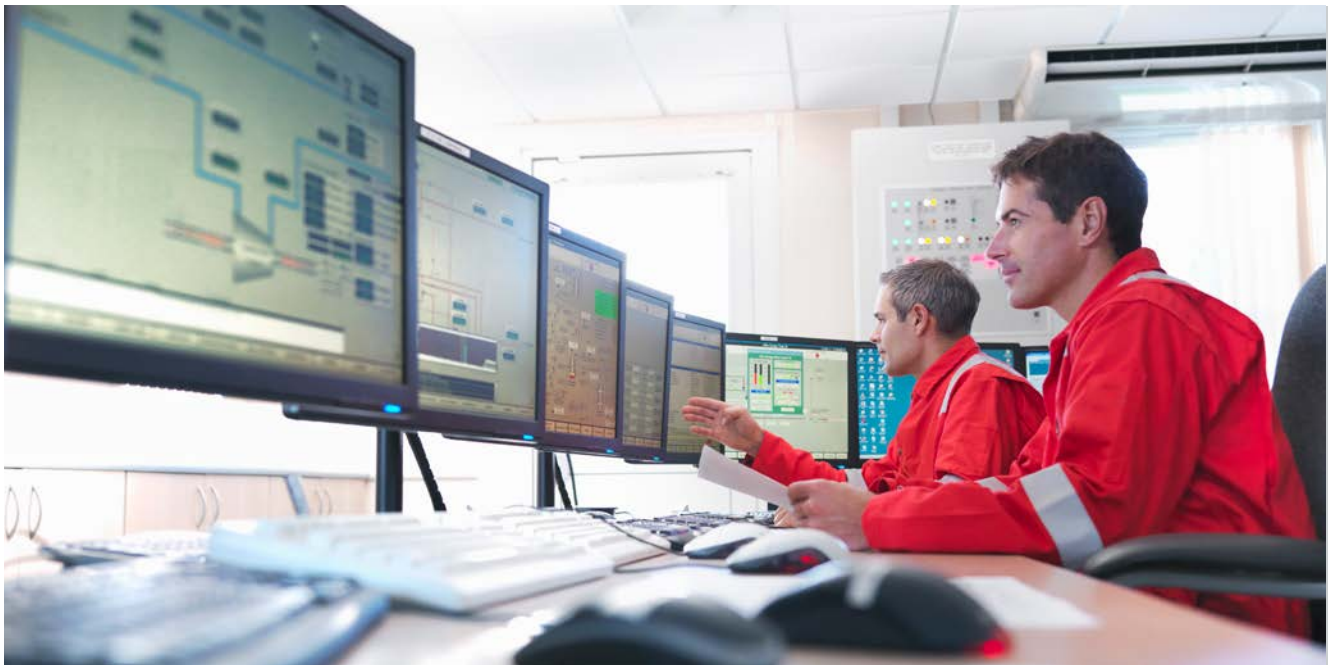
should be approved. The Federal Government expects that important milestones will be reached in the near future. Planning the corridors for the major electricity highways is progressing well. However, the exact routes for the electricity highways are not yet clear. For this reason Diagram 12.1 shows the Federal Requirements Plan Act projects Ultranet, SuedLink, SuedOstLink and A-Nord as simple straight lines. The rough outlines of these routes will be available soon. The Federal Network Agency is currently working on procedures for federal sectoral planning to this end. They form the basis for the plan approval procedures that follow, and thereby for reaching the approval goals. The Federal Government expects additional approvals in 2019 for additional projects under the Power Grid Expansion Act and the Federal Requirements Plan Act.

The Action Plan Electricity Grid submitted by the Federal Ministry for Economic Affairs and Energy will be further developed and specific measures will be incorporated. The plan contains a double strategy consisting of better utilization of the existing grid and accelerated grid expansion. Technical improvements, new technologies and operating concepts as well as improved congestion management will optimize existing grids. At the same time, grid expansion will be accelerated with strategic controlling, simplifying the planning process and economic incentives. The Action Plan comprises the following building blocks:

The existing grid will be utilized better. There are a number of ways to increase the efficiency of the existing grid. This can be done with existing technology. This includes in particular systematic and widespread monitoring of overhead cables in real time and constructing phase shifters that manage current flows to better utilise existing power grids. This is dependent on rapidly implementing the approved measures of the NDP.

Digitisation and technical improvements provide new possibilities, even for grid operation. Automation of power grids can play an important role. Newly automated operation systems that detect and remedy power line overloads in fractions of a second could help to better utilise existing safety reserves. In addition, new digital technologies can also help to better manage power flow in the grids and to distribute loads more evenly over the power lines. The goal is “smart grids”.

Congestion management will be optimised and costs reduced. Feed-in management will be adapted to conform with new legal requirements, and will be converted into a uniform regime with redispatching, so that optimisation of congestion management is carried out uniformly by transmission system operators, while at the same time maintaining priority access. The planned legislative adjustments make it possible if needed to curtail production at renewable energy and CHP plants that function well for relieving congestion, even if the potential for less effective conventional plants is not yet exhausted in a particular case. This makes congestion management more efficient: overall



fewer plants will need to adjust their input volume and be compensated for it. The costs of congestion management will go down. Planned legislative adjustments will also require that in the future all plants are regularly scaled back or started up on the basis of grid load forecasts. The grid operator curtailing output at a plant must replace the curtailed volumes. This enhances system security. At the same time, it puts an end to the unequal treatment of renewable and CHP plants compared with conventional power plants. Up to now only conventional plants have been included in scheduled, compensated congestion management. This legislation amends the Incentive Regulation Ordinance to ensure that, under certain conditions, costs incurred by network operators for preparing for the new system are taken into account when revenue caps are set. The introduction of the new procedures must be well prepared. In addition, until the new regulation enters into force on 1 October 2021, a reasonable solution should be found and implemented regarding the treatment of all costs of congestion management. The Federal Network Agency will present a report by September 2019 on feed-in management and redispatching costs and will put forward a proposal on how to include these costs in the incentive regulation.

- **Strategic controlling will be introduced.** The federal level and the Länder have agreed to create strategic controlling of network expansion programs. The goal is that the programs can be completed on time. For each program the participants (Federal Network Agency, the Länder and the project sponsors) will first work out a specific schedule that clearly defines milestones and responsibilities. The controlling will then ensure that hurdles to the individual projects are recognised early on and measures are taken in time to avoid delays in network expansion.

- **Statutory measures accelerate network expansion.** With the proposed draft legislation on accelerating network expansion (law to amend the Grid Expansion Acceleration Act), numerous changes to the law were suggested, some with immediate and some with long-term effects on accelerating the planning and approval procedures. The basic substance of the changes is simplification and acceleration of approval procedures for optimisation, reinforcement and expansion of power lines. Approval procedures already in process will be simplified. Furthermore, with foresightful planning, future plans for additional expansion of the transmission network can be factored into ongoing procedures.

- **Planners will then assess whether and how the legal framework can provide effective monetary incentives for cost-efficient optimisation of the electricity grid and grid expansion.** Accompanied by a dialogue conducted with various branches of industry, recommendations are to be worked out by the end of 2019 for creating regulatory incentives for reducing congestion management. Approaches should also be discussed for linking grid expansion and redispatching costs (bonus systems); in essence, more power line construction also means less congestion management.

As the energy transition continues, non-transmission services must also be continually developed. In addition to developing technical rules, efforts must be made to ensure that non-transmission services can also be provided cost-efficiently. To this end, evaluations are currently being conducted as to whether provision of voltage stability could be more economically efficient if idle power were compensated.

13 Integrated development of the energy system

13.1 Where do we stand?

Sector coupling is an important option for helping achieve energy and climate goals, and is the object of multiple funding programmes. The Federal Government supports innovative technologies with various programmes that enable sector coupling, for example under the Market Incentives Programme for heating with renewable energies, the CO_2 Building Rehabilitation Programme and the Heating Networks 4.0 funding programme. For the SINTEG Programme a regulation with experimental options was created that enables participants to experiment with sector coupling in practice (SINTEG Regulation).

Key measures taken to date for sector coupling

- Market Incentives Programme for heating with renewable energies
- Electric mobility eco-bonus
- Promotion of heat pumps
- Low-temperature heat networks with seasonal thermal energy storage
- Promotion of innovative CHP systems under the CHP Act
- SINTEG Regulation

Heating networks are key in decarbonising the heating supply. They make it possible to combine various technologies for reducing CO_2, such as geothermal and solar thermal power, large heat pumps or waste heat recovery. At the same time they can serve as heat accumulators and thereby provide the flexibility required for transitioning to heating supply that functions well in the framework of the energy transition. In particular, in dense construction in urban areas and historic city centres with construction restrictions, pipe-based heating supply for buildings allows for use of high percentages of renewables and waste heat from industrial or commercial use. In addition, heating networks are especially efficient at providing renewable energies, since several buildings or neighbourhoods can be supplied at once. In connection with large heat accumulators, heat networks make it possible to economically store renewable energy heat seasonally.

Key measures taken to date for the heating transition

- Pilot Project Heating Networks 4.0 Funding Programme
- bids for innovative CHP systems
- promotion of heat pumps

Digitisation is changing the structure of the energy sector in major ways:

- Digitisation allows for structural solutions for complexity. Numerous energy providers and consumers are becoming active participants in developments in the energy market. Digital connectivity is the basic condition for operating the decentrally organised energy supply systems of the future, including the optimal integration of renewable energies into the electricity system. It is absolutely essential for integrating consumers flexibly in the grid, and for scaling back the need to expand to grid to a reasonable level.
- Intelligent metering systems are the basis for digitisation of the energy transition. At the heart of this process is the smart meter gateway certified by the Federal Office for Information Security – a platform that can be used broadly for all energy transition related applications. It satisfies the strictest data protection and security standards.
- Digitisation allows consumers to have more say in how, where and when they generate or consume their own energy. It facilitates easier and more exact metering of energy consumption, which is a major step in increasing energy efficiency.
- Digitisation makes it possible to develop new business models and lower systems costs and transaction costs for administrative processes.

The Federal Ministry for Economic Affairs and Energy started its own monitoring of the digitisation process with the project Digitisation of the Energy Transition: Barometer and Major Topics (Digitalisierung Energiewende: Barometer und Topthemen), launched in October 2017. An annual barometer provides an overview of progress of implementation of the Act on the Digitisation of the Energy Transition. In addition, expert reports are prepared for major topics: How can digitisation make consumers actors 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? 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 first Barometer was published in January 2019. It reported that progress has been made regarding various aspects of digitisation of the energy sector. For example, the first certification of a smart meter gateway was an important intermediate step toward the obligatory roll-out of intelligent metering systems. At the same time, the experts commissioned by the Federal Ministry for Economic Affairs and Energy still see room for improvement in implementing the system and platform as provided for in the Act on the Digitisation of the Energy Transition.

The expansion of electric mobility and more emphasis on flexible consumer appliances (e.g. home storage, heat pumps) can impose major burdens on the distribution grids. If used well, however, these new, flexible loads can provide the opportunity to counteract the volatility of renewable energy generators, and to increase the stability of the electric system. In this way existing grids can be uti-

lised better and the demand for expansion reduced. Digital communication in a smart grid is one of the major applications for intelligent metering systems. The Federal Ministry for Economic Affairs and energy is currently working on draft regulations that utilise the advantages of digitisation for introducing flexibility to distribution grids, sector coupling and integrating electric mobility into the networks. These drafts are to provide the groundwork for discussions taking place in the second half of 2019 regarding what changes must be made in the legal framework.

Modern metering equipment has been available in the market since the beginning of 2017. This has encouraged the move away from electromechanical meters (Ferraris meters). Modern metering stations are defined by Section 2 no. 15 of the Metering Act as digital metres that can be safely connected to a communication network through a smart meter gateway. There are already such devices installed in around 560,000 meter points. In 2016, there were only 50,000 such metering devices in use.

In the first two years of the SINTEG Funding Programme the major emphasis was on creating the foundation for a number of innovative projects. Two of the projects that were tested for the first time were platforms on which provision of flexibility, previously mostly in the industrial area, can be traded. The goal is to avoid congestion by adapting energy consumption. In the remaining project period ending at the end of 2020 practical experience will be acquired in a number of various test applications.

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 has taken important steps towards defining the framework for digitisation in the power sector. However, the energy transition and the transport transition require more than just "intelligent metres". It is therefore important to move beyond simple metering functions to the path to smart grids, smart mobility and smart homes and to take full advantage of digitisation. 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.

Key measures taken to date for digitising 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
- SINTEG Smart Energy Showcases – Digital Agenda for the Energy Transition
- Energy Savings Meter pilot programme
- Strategy for Automated and Connected Driving
- Digitisation as a cross-section topic of the 7th Energy Research Programme

13.2 What is next?

Sector coupling will continue to open up new potential for efficiency and reduce the use of fossil fuels. In order to reach the long-term goal of a mostly greenhouse gas-neutral energy supply, it is increasingly important to further reduce overall energy demand with such cross-sectoral efforts ("Efficiency First" principle) and to make the power system even more flexible. In the case of applications that

do not offer easy options for reducing greenhouse gas emissions (for example in the aviation and sea transport sectors or for some industrial processes), sector coupling technologies remain an important option for achieving energy and climate goals. This potential has obviously not been optimally tapped under previous conditions. This is indicated at least by the mixed results of trends up to now. Heat pumps have become more important, yet Germany has far to go in electrification of vehicle drives, with the exception of rail traffic.

It will be a challenge for the heating transition to keep pace with the goals and objectives of the EU for 2030. The obligational targets for 2030 in the national heating sector are set out in the specific emission reduction targets of the 2050 Climate Action Plan for buildings and industry (process heat and cooling) at the EU level in the amended efficiency, renewables and buildings directives in the Clean Energy for All Europeans legislative package. This contains obligatory measures for renewable energies in the heating and cooling sectors that should help to increase the renewables share by 1.3% annually. In heating networks the renewables share should increase by 1% annually.

The potential of digital technologies will develop exponentially in many areas. New technologies such as blockchain, artificial intelligence or quantum computing can propel digitisation to new levels and improve the prospects for new applications and means for analysis, controlling and automation. This will have a substantial impact on structures and processes of the energy industry. Many companies in the energy industry and research institutions are already testing possible applications of blockchain technology in pilot projects, especially in the area of energy trading. The AI strategy and the blockchain strategy of the Federal Government planned for the summer of 2019 will continue to accelerate these developments.

Integrated development of the energy system is essential for the energy transition. To achieve this, the framework must be quickly adapted and planning reliability ensured. There is significant potential in the areas of research, development and demonstration to further enhance sector coupling technologies. To take advantage of this potential, the 7th Energy Research Programme of the Federal Government has a focus on linking various sectors while researching technologies and plans for sector coupling. In addition the current idea competition Living Laboratories of the Energy Transition is focussed on Sector Coupling and Hydrogen Technologies. Furthermore, various sector coupling technologies are already being sponsored with existing funding programmes such as MAP and industry funding programmes. These programs are made even more attractive and efficient with funding strategies of the Federal Ministry for Economic Affairs and Energy. Ultimately, sector coupling technologies should be used that are competitive in the market. In order to improve the conditions for sector coupling, the Federal Government will evaluate the effectiveness of existing components of energy prices mandated by the government in form of charges, fees and taxes.

The Federal Government will promote the heating transition. Corresponding measures should become important elements of the NAPE 2.0 package planned for the 2021–2030 decade. The Federal Government will concentrate basically on three areas when implementing the heating transition:

- creating and modernising heating networks
- improving energy efficiency and using renewable energies in industry and trade
- measures for creating low-carbon heating supply for the buildings sector, especially for existing building stock.

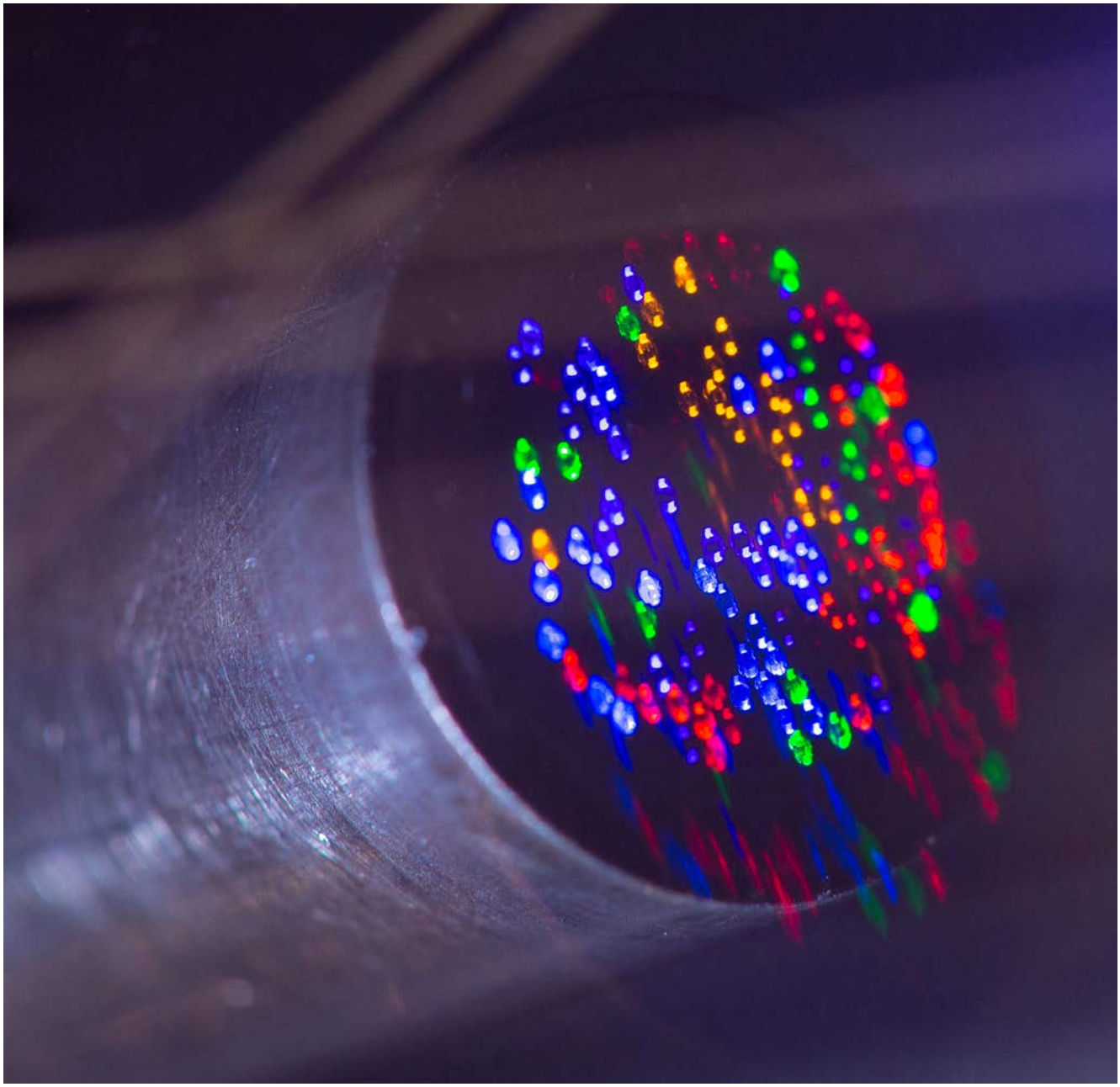
The heating transition makes it possible to generate value added where German companies are traditionally strong: with technically sophisticated and systemically smart solutions. Because the heating sector is largely dependent on local conditions, the low-carbon heating supply of the future will not be based exclusively on one technology, rather a mix of improved energy efficiency and various technologies such as heat pumps, geothermal and solar thermal energy, as well as energy storage technology. This makes it possible to provide the necessary flexibility and at the same time ensure that the heat supply is secure. Total energy consumption for heating purposes must be drastically reduced, direct thermal use of renewable energies must be better exploited and the remaining demand satisfied with sector coupling.

Creation of newer, more modern and more efficient heating network is one means, but modernisation of existing heat networks also holds unexpected potential. For this reason, it is important for the future to provide impetus for transforming existing networks and to focus it on decarbonisation of heating supply. In addition to creating incentives with funding programmes in the efficiency and buildings area, the “Energy Efficiency and Heating with Renewable Energy” assistance program run by the Federal Ministry for Economic Affairs and Energy also has a funding programme for heating infrastructures. In addition to the Heating Systems 4.0 programme, the new heating infrastructure funding programme aims to assist in modernising existing heating networks, improving their efficiency and making them compatible with the energy transition. This requires using renewable energies and waste heat.

Regarding digitisation this means in particular tapping the potential created by the Act on the Digitisation of the Energy Transition for all areas of the energy transition. Smart meter gateways will be established as platforms for the energy system based on renewable energies. In order to exploit the full potential of smart metering systems in all operating environments, it is imperative to continually develop minimum technical standards. The Standardisation Strategy for Cross-sectoral Digitalisation of the Energy Transition (Roadmap) published by the Federal Ministry for Economic Affairs and Energy and the Federal Office for Information Security describes this process. The standardisation strategy defines all necessary technical standards for applications, for example feed-in and load management (smart grid) and electric mobility (smart mobility) one by one, as required for secure and efficient digitisation of the energy transition. The Metering Act, as part of the Act on the Digitisation of the Energy Transition, provides for continual, progressive expansion of smart meter gateways to all applications relevant to the energy transition. This calls for minimum standards that can keep pace with the requirements of the energy transition, ensure value added for the consumer, across all areas and in the sense of sector coupling (in particular heating, smart homes), involve electric mobility and be designed to deal with threat scenarios, for example hacking. The roadmap will be continually updated in close cooperation with the relevant actors.

Impetus for new solutions and business models can be expected from funding for development and testing of new digital applications from the SINTEG Funding Programme, the Energy Saving Meters Programme and funding for energy research. In addition, the energy sector demonstrated a significant dynamism in start-ups in past years, which enables new participants to establish themselves in the market. The Federal Ministry for Economic Affairs and Energy will actively support new technologies, for example in the area of blockchain and creation of new business models, in order to make any necessary changes to the regulatory framework early on. Furthermore, the framework for start-ups in the energy sector will be continually improved to support the dynamism of the start-up scene, and to allow for quicker scaling of economically and systemically meaningful business models for the integrated energy transition.

14 Energy research and innovation



14.1 Where do we stand?

Business investment for research and development in the area of innovative energy technologies under government research programs continued to increase in 2017. Within the framework of publicly funded energy research projects alone, businesses invested around €213 million in the development of innovative energy technologies in 2017, compared with €155 million in the previous year. 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 far higher than this. The energy sector spent €2.75 billion on energy research and development in 2017, according to the Association for the Promotion of German Science and Humanities (Stifterverband für die Deutsche Wissenschaft).

Industry-oriented energy research safeguards the competitiveness of German industry. In applied research and technological development the focus is on industrial applications. These programs are conducted in close cooperation between the research institutions and universities. In total, industry participated in 46% of all current research projects on applied energy research in 2017. Industry also committed €206 million to newly approved research projects.

Horizon 2020, the European research and innovation framework programme, is given high priority in Germany. German applicants received 15.7% of total funds, around €376 million.

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 around 30% to less than 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.

Key measures taken to date 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
- Strategy for Automated and Connected Driving
- Electric Mobility Showcase
- Programme to promote PV battery storage units

14.2 What is next?

Energy storage is becoming increasingly important with the continually growing share of renewable energy in the energy supply. The last projects of the joint Energy Storage funding initiative conducted by the BMWi and the BMBF were 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.

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. There are plans in particular for specific funding for energy research on developing industry processes that are low in CO_2 emissions or on CO2 closed cycles. One example is the Carbon2Chem project initiated by the Federal Ministry of Education and Research to provide financial assistance for research on a global solution for economic recycling of blast-furnace gas using renewable energy. In addition, the MACOR project sponsored by the Federal Ministry of Education and Research contains a feasibility study on large-scale integration of hydrogen-based direct reduction in an existing smelting process.

Energy research will become even more important going forward. Current financial planning has earmarked approximately €6.4 billion for energy research in the scope of the 7th Energy Research Programme for the period 2018 to 2022. For 2020 a volume of approximately €1.3 billion is planned, of which €863.1 million will go to project funding.

To efficiently implement the energy transition and to cost-effectively achieve the ambitious energy and climate goals, immediate and strongly focused research and development is required. This positive trend will continue and will strengthen the role of energy research in the context of the Federal Government's energy policy.

Future areas for focus in research and development are especially the following:

- low-carbon energy production and technologies for buildings, industry and transport

- technologies for using renewable energies in the heating and electricity sectors
- sector-coupling technologies to reduce carbon emissions in buildings, industry and transport
- technologies for reducing carbon dioxide emissions from industry processes; the creation of CO_2 closed cycles is a long-term perspective.

It is important to combine existing and new technologies across sectors, to take advantages of opportunities provided by digitisation, to allow for new business models and to involve more and more actors in the process. The 7th Energy Research Programme provides the basis by strengthening technology and innovation funding in the energy area, extending this funding to include societal and systemic approaches and thereby focusing on the major trends: sector coupling and digitisation.

To support the transfer of practical experience in innovative energy technologies such as power-to-x, and to enable new approaches to regulatory issues, the Federal Government will set up Living Laboratories of the Energy Transition as new pillars of research promotion. These Living Laboratories will take on the major systemic challenges of German energy policy in clearly defined large-scale projects. They will be pioneers for the transformation of the energy system and will be dedicated to research issues that play a key role in implementing the energy transition. This initially includes sector coupling technologies such as large-scale electrolysis plants using waste heat in grid congestion areas, large thermal storage facilities for carbon-free sustainable exploitation of existing energy infrastructures, technologies for carbon use or smart networks for energy infrastructure in climate-neutral urban quarters. These living laboratories will not only be larger and address more topics than previous demonstration projects, but will also open up new paths to "regulatory learning". In this manner, technological and regulatory findings can be put to practical use in both areas, and reveal potential for systemic optimisation.

At the same time, startups as important sources of impetus for the energy transition should receive more support. Startups are highly focused, dynamic and are subject to the pressure to succeed from their investors. The classic instruments and mechanisms of project funding are however currently not suited to these actors. If startups are not included more strongly in energy research, an important driver of innovation will be left out of the process. For this reason, the Federal Government aims to appeal more strongly to startups with new and adapted funding formats and to increase their participation in all topics of energy research. Existing hurdles will be removed successively:

- by expanding the programme to non-technical innovations (business models, new services) related to technical improvements;
- by adapting and accelerating administrative procedures, for example with specific startup advisory services and a "fast track" option for applications;
- with new, more agile project customization and competition formats; and
- with the new networking platform Research Network for Energy Startups (Forschungsnetzwerk Energie Startups).

Just how important networking is for startups was also illustrated by the successful completion of the Startup Energy Transition Laboratory in December 2018. This project run jointly by dena (German Energy Agency) and the Federal Ministry of Economic Affairs and Energy offered young and innovative companies a forum for presenting ideas for further development of the energy system and to have dialogues with experts from government and industry.

In the international and European context too, Germany will continue to push for a holistic approach geared towards the transformation of the energy system. With its 7th Energy Research Programme the Federal Government wishes to create a strong research network at the international and European level. The Energy transition is and will remain a global challenge. In the context of EU programmes such as Horizon 2020, this also helps to strengthen European competitive power. Starting in 2021, the new, 9th EU Framework Programme will continue the efforts of this programme with a new approach. This shows that the energy transition is becoming more and more European.

15 Investment, growth and jobs

15.1 Where do we stand?

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. This makes Germany less dependent on fossil fuel imports. In addition, diversification of energy sources and transport routes for fossil natural resources will remain a high priority for the Federal Government.

In 2017 the energy industry again invested large amounts in the transition of the energy system. This applies in particular to electric grids, plants using renewable energies and energy efficient building refurbishment.

Indirect investment effects for industrial energy consumers may be attributable to electricity and power expenditures or possible price increases. For example, German electricity prices have been high by international standards for a long time, which is in part a reason for low investment activity in energy-intensive industries. Gross investment in these industries – including in particular the sectors paper, glass and ceramics, chemicals, metal production and processing – has gone down every year since 2002. In order to prevent the energy transition from contributing to this general trend, energy-intensive industries that are faced with international competition receive various types of compensation. These industries were able in part to profit from declining electricity prices in 2017.

Investments made as part of the energy transition have a positive impact on growth. Owing to the interdependencies of intermediate inputs, these investments generate value added in many areas of the national economy.

With more renewable energies and attempts toward energy efficiency, there is less need to import fossil fuels. One benefit of the energy transition is lower expenditures for fossil fuel imports. The demand for imports of fossil fuels would have been higher in the absence of investments in renewable energy and energy efficiency efforts. According to estimates of the GWS, renewable energies and energy efficiency dampened imports of fossil fuels in 2016 by about €16 billion. This effect will probably have been strengthened in 2017 by the rise in fuel prices that year. In this respect, estimates of the IEA for 2016 conclude that the annual energy expenditures of private households in Germany would have been €500 higher per capita without progress that has been made in energy efficiency. Long-term savings of a similar magnitude can also be expected from diversification of energy sources and transport routes for natural resources. Accordingly, this remains a priority of the Federal Government.

German investment goods for the energy transition are exported. In recent years a marked shift from domestic to international demand took place in Germany for energy plants and components for utilising renewable energies. However, in comparison to the previous year (2016: €12 billion) exports dropped in 2017 to €8 billion; net exports were €3.4 billion. One reason for the strong dip is the downward trend in markets in which German companies had been active in past years; in addition, these companies could not hold their previous competitive position in the new growth markets. However, if we look beyond goods related to the energy transition to the larger environmental and climate protection goods market, German companies are still global leaders in exporting these technologies.

Direct employment in the energy sector remained stable in 2017. Investment activities in the energy industry continue to involve high employment. Investments in the area of energy demand also generate employment. Employment figures in the area of renewable energies amounted to a total of 317,000.

15.2 What is next?

Investments are a key to finding growth and employment possibilities in the German economy and also remaining competitive in the future. Investments in coming years will determine whether Germany can continue to provide a modern and powerful infrastructure and ensure the success of the energy transition. For transitioning to a viable energy system investments will be continually required, especially in the areas of energy efficient building refurbishment and electricity supply. Annual investments in the double digit billions will provide additional impetus for more growth and employment in Germany. The Federal Government creates transparent and stable conditions for investment. This increases investment and planning security, which in turn has a positive effect on investment decisions of companies and the economic viability of innovative business models.

This will also help German companies to remain leaders in international markets. Export opportunities are created by the amendment of the EU Renewable Energy Directive, for example. This directive contains the ambitious goal of increasing the share of renewable energies in gross final consumption of energy in the EU to 32% by 2030, which provides additional momentum to demand for related technology. German companies that wish to tap markets outside the EU receive assistance from the Federal Government in the form of export subsidies, such as the Energy Export Initiative. The cooperation within energy partnerships and dialogues also provide important contributions to export promotion. In addition to enabling consultation with partner countries in expanding renewables, international partnerships also provide a platform for innovation "made in Germany".

Previous studies concur that the energy transition has had a positive effect on employment. One particular focus is currently on the coal-mining areas that are faced with rapid structural changes due to the phase of coal-fired power generation. The Federal Government will spend substantial amounts together with the Länder to help these regions to create new value-added chains and sustainable employment opportunities. If there is a lack of skilled workers in implementing the energy transition, this will be counteracted with a suitable monitoring and regulatory framework.

The energy transition will contribute to lasting prosperity and quality of life. Overall, the energy transition provides many benefits, some of which however are difficult to express in macroeconomic terms. For example, the energy transition is beneficial in that greenhouse gas emissions and air pollution are reduced, thereby reducing the negative impacts on humans and the environment. With the energy transition the Federal Government creates the necessary prerequisites for growth, employment and innovation, on the one hand, and on the other, also ensures lasting prosperity and quality of life. At the same time, the energy transition must be seen in a global and holistic context. Holistic means that the energy transition is successful in all sectors and that the socio-economic aspect is always part of the equation.

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