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Climate Action in Figures

Facts, Trends and Incentives for German Climate Policy
2017 edition

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1. Summary

Why is Germany committed to climate action?

Climate change is tangible in Germany in the increasing number of extreme weather events, among other things. The **macroeconomic losses** due to the heat wave in 2003 have been estimated at **13 billion euros**. At the same time, this heat wave led to approximately **7,000 additional heat-related deaths** in the south-west of Germany.

If the greenhouse gas emissions that harm the environment are not restricted, **global warming** could increase to **4 °C** or more **by 2100**.

Since the beginning of industrialisation, Germany has contributed **almost five per cent** to global warming with its greenhouse gas emissions, although the **German population only makes up roughly one per cent** of the world population.

What are the current climate action targets?

The historic Paris Climate Agreement is the first to oblige all contracting parties – in addition to all industrialised countries, this also includes developing and emerging countries – to adhere to emission reductions binding under international law from 2020 on, to keep global **warming significantly under 2 °C** and to pursue efforts to restrict it to **1.5 °C**.

With the "national contribution", which the EU Member States submitted to the United Nations for the Paris Agreement, the EU Member States commit to a pan-European **emission reduction** by 2030 of **at least 40 per cent** compared with 1990. This goal is embedded in the EU's long-term climate action target of reducing EU-wide **greenhouse gas emissions by 2050** by **80 to 95 per cent** compared with 1990.

Germany set milestones in the Energy Concept 2010 and the Climate Action Plan 2050. By 2050, the greenhouse gas emissions are to be reduced by at least 80 to 95 per cent compared with 1990, the **percentage of renewables** in final energy consumption is to increase to **60 per cent** and the **primary energy consumption** is to reduce by **50 per cent** compared with 2008.

To contribute to meeting the 2 °C or even the 1.5 °C cap, **by 2030**, German **greenhouse gas emissions** must be reduced in all sectors by at least **55 per cent** compared with 1990.

How are emissions in Germany developing?

German greenhouse gas emissions of 902 million tonnes of CO_2 equivalents in 2015 represent a **reduction of 27.9 per cent** compared with 1990.

At **38.5 per cent, the energy sector** accounted for the largest share of the overall emissions in Germany once again in 2015.

The emissions in the **industry sector** are responsible for **one fifth** of the German greenhouse gas emissions, and have only decreased slightly since 2010. The European emission trading system (EU-ETS) currently covers half of all German emissions.

The **transport sector** causes **just under 18 per cent** of emissions in Germany. Road traffic causes roughly 96 per cent of these emissions.

Private households (sector share: ten per cent) have already reduced emissions by **approximately 35 per cent** between 1990 and 2015, but these increased slightly compared to the previous year due to the weather.

The greenhouse gas emissions in the commerce / trade / services (CTS) sector (sector share: four per cent) have decreased roughly 54 per cent since 1990. At over **70 per cent**, the highest reduction in emissions since 1990 was achieved in the waste management sector (sector share: one per cent). With re-use and recycling, Germany is already paving the way in implementing a climate- and resource-friendly circular economy.

The percentage of German emissions from the **agricultural sector** increased slightly again to **over eight per cent** in 2015. This is due in particular to methane and nitrous oxide emissions, which result from dairy farming and use of fertiliser, among other things, and have a very strong effect on the climate.

The **land use, land use change and forestry sector** reduced emissions in Germany by **14.5 million tonnes of CO_2 equivalents** in 2015. However, compared with 1990, agricultural soils and forestry now only store roughly half as much greenhouse gas emissions.

What does climate action mean for the economy and society?

Investments in climate action also drive job growth. The Federal Government's Climate Action Programme 2020 aims to create **430,000 additional jobs** in the next few years. The renewable energy sector already provides **more than 330,000 jobs** today.

Significant investments are currently being made in the building sector. In 2015, roughly **36.4 billion euros** were invested in **refurbishing** existing residential buildings alone; a further **16.8 billion euros** were spent on refurbishment of non-residential buildings.

Various support schemes back climate-friendly innovations. As part of the high-tech strategy, the Federal Government invested **14 billion euros** in **innovation promotion** in 2014/2015.

In 2015, the expenditures for **fossil energy imports** decreased significantly once again. Overall, the value of fossil fuel imports totalled **roughly 57 billion** euros, compared with **roughly 81 billion euros** in the previous year.

Three-quarters of all Germans live in **cities**. That is why there is a lot of information and many climate initiatives for cities and municipalities.

Private stakeholders can contribute to climate action with their purchasing power. The "**Blauer Engel**" helps consumers make choices by identifying over **12,000** environmental- and climate-friendly **products and services**.

2. Why is Germany committed to climate action?

2.1 Climate change – Impacts and adaptation

Extreme weather events and other impacts of climate change are becoming increasingly frequent

Climate change is already tangible, even in Germany. In 2015, human activities, such as burning fossil fuels like coal, crude oil and natural gas, had raised the global average temperature of the earth by more than 1 °C compared to the level prior to the industrial revolution. If the greenhouse gas emissions that harm the environment are not restricted, global warming could increase to 4 °C or more by 2100. However, the Intergovernmental Panel on Climate Change (IPCC) warns against exceeding the 2 °C threshold. If global warming exceeds 2 °C, climate change damage will be irreversible and no longer manageable.

The impacts of climate change include droughts, floods and melting glaciers. Today, heat waves now occur four to five times more frequently than before the beginning of industrialisation; 2016 once again exceeded the global temperature record set in 2015. In addition, the frequency and intensity of extreme precipitation in Europe has increased.[1]

The number of extreme weather events in Germany has already more than tripled since the 1970s. Globally, Germany was one of the 20 countries most frequently affected by extreme weather events between

1994 and 2014. The Danube and Elbe floods in 2002 and 2013 caused damage to the national economy totalling roughly 20 billion euros. After the flooding caused by torrential rain at the end of May 2013, many main railway lines were closed for months, for example. In 2016, the storm fronts "Elvira" and "Friederike" in Baden-Wuerttemberg and Bavaria caused insured damage totalling roughly 1.2 billion euros. The total estimated damages were many times higher.[2]

Climate change can endanger biodiversity in Germany. Rising temperatures and changed seasonal weather impact the regional proliferation and composition of species communities in flora and fauna. Animal species from warmer regions, which were previously rarely or never found in Germany, adversely affect domestic ecosystems and can cause high economic costs as well as endangering human health.

Heat stress is a growing health risk. The number of "hot days" (peak temperature of at least 30 °C) has risen from roughly three days per year in the 1950s to a current annual average of eight days. Small children and older and ill people suffer particularly from this. The heat wave in summer 2003 caused roughly 7,000 additional heat-related deaths in the south-west of Germany. As longer and more intensive heat events can be expected to occur more frequently here, the probability of more heat-related mortalities is also rising in a similar order of magnitude as in 2003. Furthermore, heat stress also impairs the ability of employees to work and their productivity.[3] Figure 01 shows the expected effects of climate change on the various regions in Germany.

Heat waves also have economic consequences. Overall, the macroeconomic losses due to the heat wave in summer 2003 have been estimated at over 13 billion euros.[4] This was due to lower agricultural yields, as well as the destruction of forest areas via widespread fires and bottlenecks in the power supply, among other things.

"In the future we have to expect even more frequent heat waves, heavy rain and floods."
Maria Krautzberger, President of UBA (Federal Environment Agency)

In future, scientists expect a further increase in the number of extreme weather events such as heat waves and torrential rain in Germany. As a result, it is likely that the negative effects of climate change on nature, society and the economy will increase. By the end of the century, the annual damage due to flooding in Germany will double, if not triple, compared with the period between 1961 and 2000.[5]

Climate action and adaptation

Measures to protect against the impacts of climate change are becoming increasingly important. As early as 2008, the Federal Government adopted the German Adaptation Strategy on Climate Change (DAS) and then substantiated it in 2011 with the Adaptation Action Program I. The aim is to maintain or increase the adaptability of natural, social and economic systems. In December 2015, the Federal Government presented the first Progress Report to the DAS and agreed on 140 binding adaptation measures.[6]

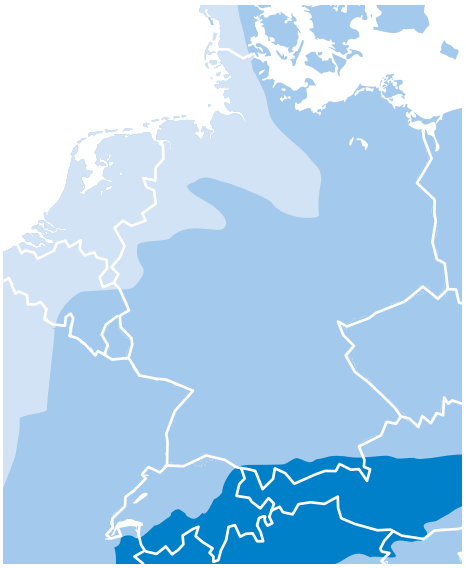
The higher the rise in global temperatures, the more expensive the adaptation measures will be. This is true for industrialised countries too. Adaptation alone is not enough. Restricting global warming as stipulated in the Paris Agreement (see Section 3.1) would limit the risks and effects of climate change, according to the Intergovernmental Panel on Climate Change. This is extremely important, particularly for vulnerable island nations and developing countries. There is also a risk that warming by more than 2 °C will lead to "tipping points", resulting in irreversible changes like melting ice caps or thawing permafrost, which in turn would further increase warming.

Figure 01: **Map of Germany on the effects of climate change**

Atlantic region
- Increasing occurrence of heavy rainfall
- Rivers increasingly carry more water
- Rising risk of river and coastal flooding
- Rising risk of destruction by winter storms
- Decrease in demand for heating energy
- Increase in many climate risks

Rural area
- Increase in extreme heat
- Decrease in precipitation in the summer
- Rising risk of river flooding
- Rising risk of forest fires
- Decreasing economic value of forests
- Increased energy demand for cooling

Mountain region
- Temperature increase above European average
- Decrease in the extent and volume of glaciers
- Displacement of plant and animal species to higher altitudes
- High risk of extinction of species
- Rising risk of infestation by forest pests
- Rising risk of landslides and rock slides
- Changing hydroelectric power potential
- Decrease in ski tourism



Source: Own diagram based on EEA (2017)

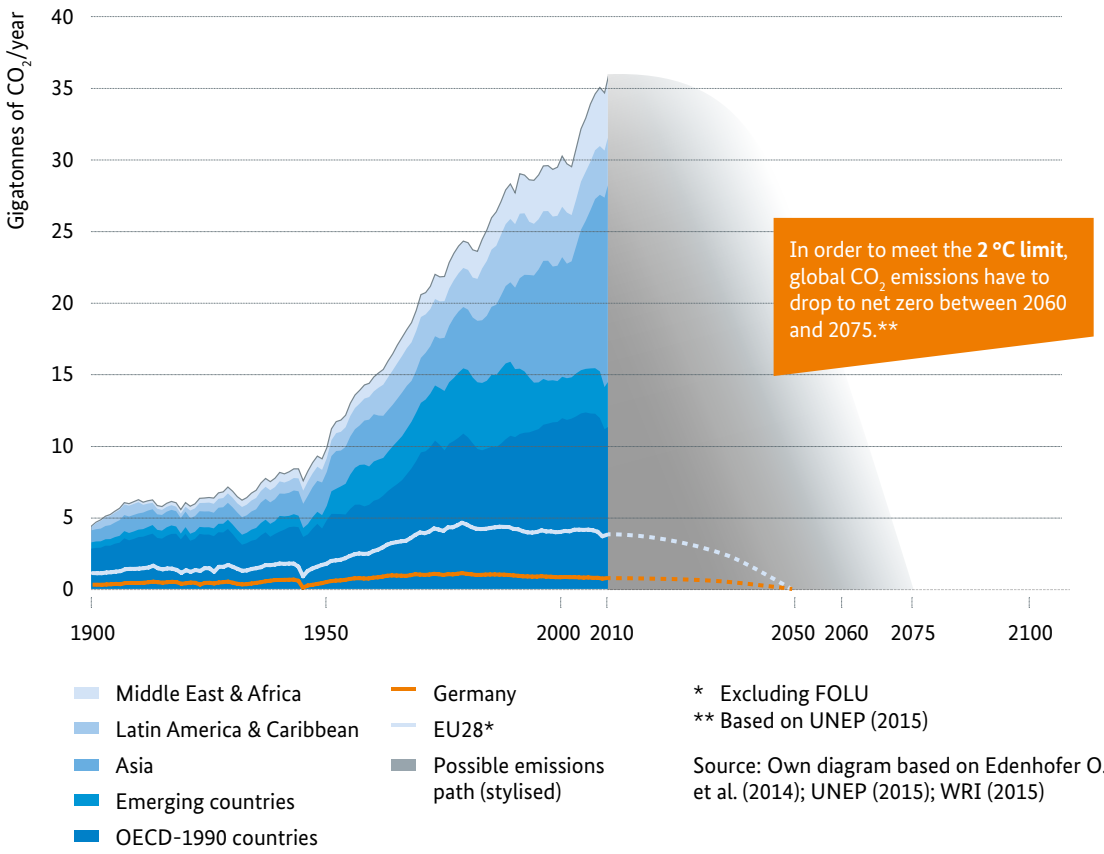
"The costs of the devastating effects of climate change are becoming increasingly difficult to bear, the more climate change advances."
Dr Angela Merkel, German Chancellor

2.2 Germany's global responsibility

Decarbonisation is an opportunity for humans, the environment and economy. It refers to a shift away from fossil energy sources to a low-carbon economy. Technologies for climate-friendly energy generation like solar energy systems have achieved significant cost reductions in recent years. Current estimates by the United Nations Development Programme (UNDP) assume that global economic growth could increase by ten per cent or 12 trillion dollars by 2050 compared with current climate policy measures, if global warming is restricted to 1.5 °C.

In the past two centuries, Germany was dependent on fossil fuels. Since the beginning of industrialisation, Germany has contributed almost five per cent to global warming,[7] although the German population only makes up roughly one per cent of the world population. While the rapid increase in emissions in recent decades can be traced back to emerging countries, if we attribute the emissions to their countries of origin, industrialised countries like Germany are historically and currently major co-originators of climate change, and have a great responsibility to restrict it

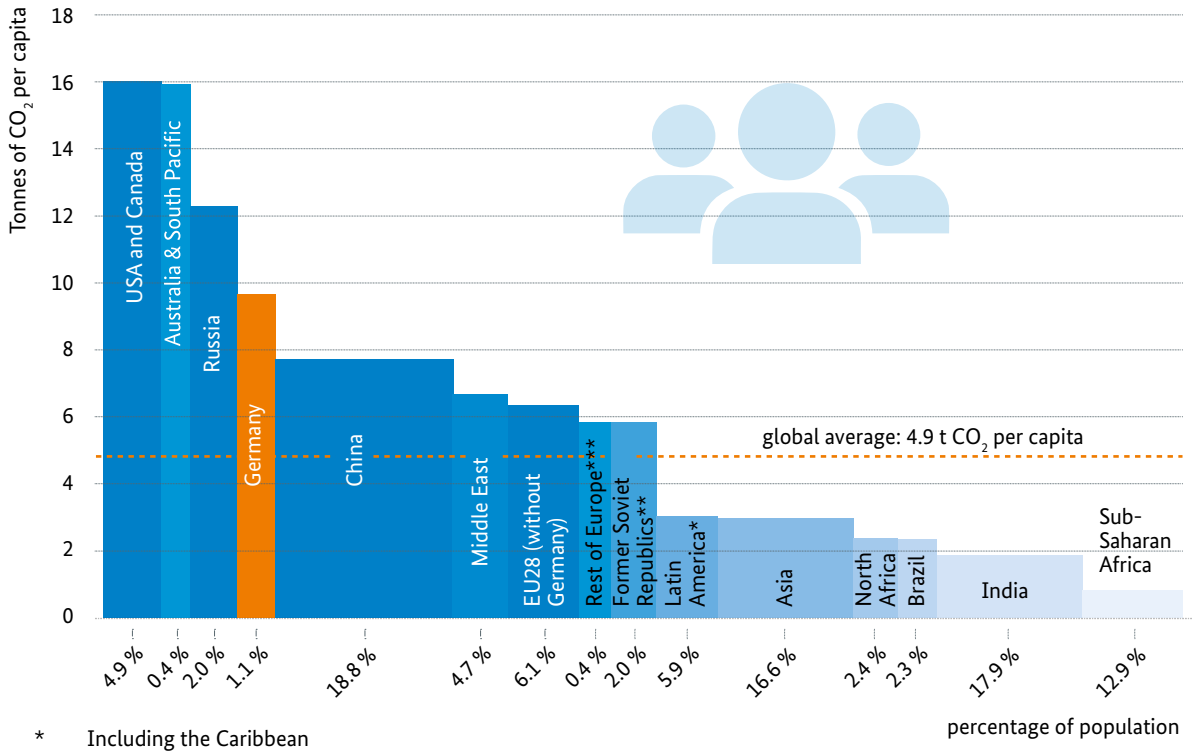
Figure 02: **Historic CO_2 emissions and savings path**



(Figure 02). To restrict global warming to significantly under 2 °C, virtually all economic sectors in Germany are to become greenhouse-gas-neutral by 2050. While the power supply can be switched to renewable energy sources completely, agriculture and the industry sector will always have some residual emissions. The German climate action target for 2050 involves a reduction of 80 to 95 per cent. The Paris Agreement sets a target of global greenhouse gas neutrality in the second half of the century.

Figure 03 shows the per capita CO_2 emissions of countries and global regions relative to their percentage of global population. Although China tops the list of absolute emissions by far (Figure 04), the per capita emissions there are still far below those of many OECD nations, at 7.6 tonnes of CO_2. The German per capita CO_2 emissions, at roughly 9.6 tonnes, are still far higher than the international average of 4.9 tonnes per capita (2015). If you also take into consideration that much of the CO_2 emission in emerging countries is based on production of exported products for consumption in industrialised countries, the consumption-based emissions in Germany are even 11 per cent above the mentioned per capita emissions.[8]

Figure 03: **International per capita CO_2 emissions by percentage of global population 2015**



* Including the Caribbean
** Excluding Russia; Estonia, Latvia and Lithuania are included in EU28
*** The rest of Europe includes Norway, Switzerland, Iceland and the Balkan States
Due to rounding, the shares of the world population do not add up to 100 %

Source: Own diagram based on EDGAR (2016); World Bank (2016)

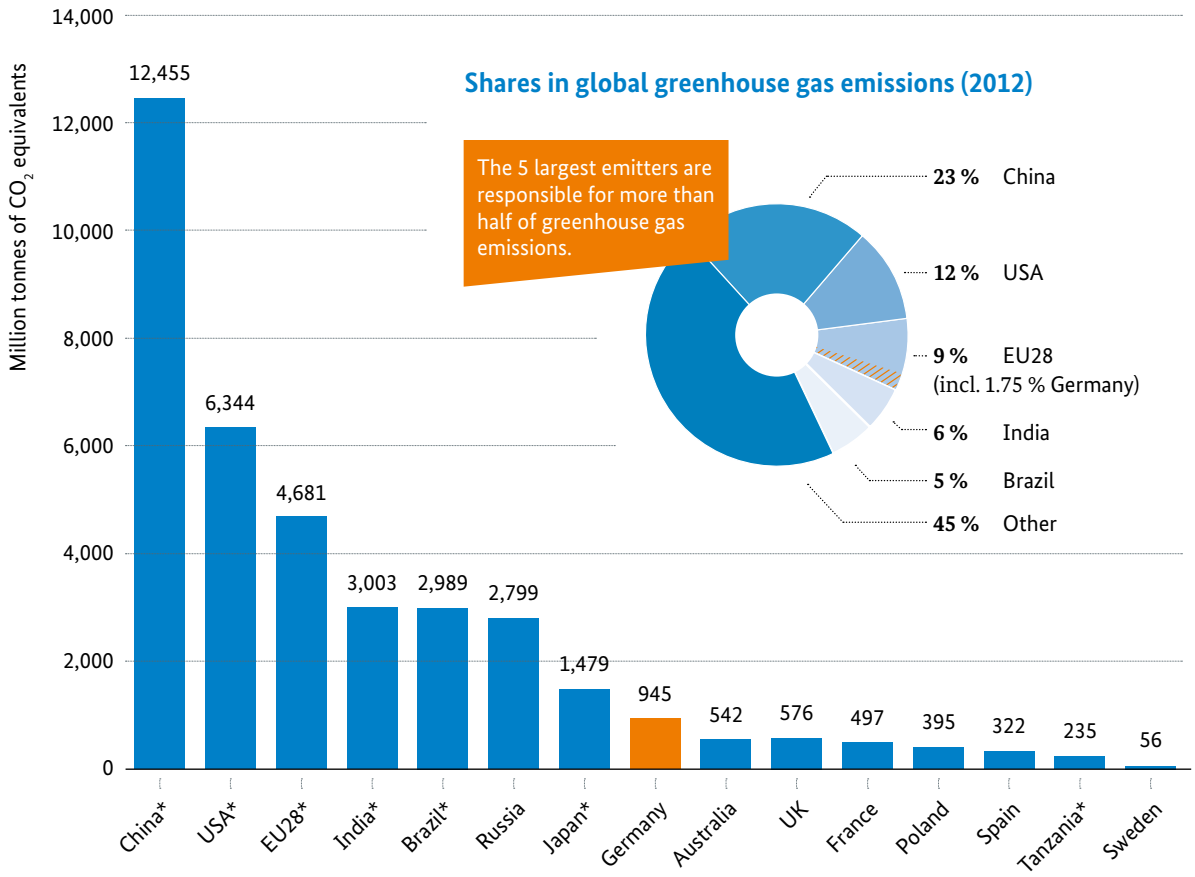
Germany is aware of its responsibility to combat climate change, vis-à-vis both vulnerable regions of the world and future generations. The impacts of climate change often most severely affect the regions and people with the least financial ability to adapt to climatic changes. The ten countries most affected by extreme weather are developing countries. There in particular, climate change endangers the foundations of life of many people who are dependent on climate-sensitive agriculture. Accordingly, climate change heightens social inequality and poses a risk of violent conflict and increased migration.

"Climate policy is active refugee policy."
Dr Barbara Hendricks, Federal Environment Minister

Germany has been actively committed to climate action since the 1990s, and, by 2016, has already made considerable advances compared with 1990:

- Decrease of an estimated 27.6 per cent in greenhouse gas emissions[9]
- Major expansion of renewable energy sources – the percentage of primary energy consumption from renewable energy sources has increased almost tenfold to 12.6 per cent today[10]
- Per capita primary energy consumption reduced by more than 12 per cent[11]

Figure 04: **Greenhouse gas emissions in the international comparison (excluding LULUCF)**



*No data available for 2013; therefore data for 2012 is presented here

Sources bar chart: 2013 data: UNFCCC (2015); UBA (2017a)
2012 data: EDGAR (2014)
Source pie chart: EDGAR (2014)

These measures also have positive effects on the economy and society, as presented in greater detail in Section 5.

In 2015, 2.7 billion euros were made available from the federal budget for technical and financial support of developing countries in climate action and adaptation measures. This support was supplemented by the German development bank KfW and the German Investment and Development Society (DEG) with a further 4.7 billion euros from capital market funds. The Federal Government strives to increase the budget funds used for climate financing to four billion euros every year by 2020, and provide other significant amounts as public sector loans (via KfW and DEG) and by mobilising private funding. This is how Germany is making its contribution to the goal of the industrialised countries to provide at least 100 billion dollars annually for climate funding in developing countries from 2020.

3. What are the current climate action targets and instruments?

3.1 International climate action policy – Implementing the Paris Agreement

International climate policy is organised in the United Nations Framework Convention on Climate Change (UNFCCC). To date, the Framework Convention has been ratified by 196 countries and the EU, which means that virtually every nation on earth is a member. Since 1995, the contracting parties have alternated in hosting annual conferences, known as "Conferences of the Parties".

The Kyoto Protocol was signed at the third Conference of the Parties in 1997 in Kyoto (Japan). It entered into force in 2005. In it, some of the industrialised countries, including all EU Member States, committed to binding emission reduction targets by 2012 and in a second phase by 2020. That made the Kyoto Protocol the first legally enforceable international climate agreement with quantifiable emission reduction commitments. In the past decade, the focus has been on negotiating a follow-up agreement for the Kyoto Protocol from 2020 on. This was finally achieved at the 21st Conference of the Parties in Paris in December 2015.

"We have today reassured our future generation that we all together will mitigate the challenge posed by climate change and we will give them a better future." Prakash Javadekar, Indian Environment Minister, on the Paris Agreement

Key targets of the Paris Agreement

2 °C cap: In the agreement, the global community – including developing and emerging countries for the first time in addition to all industrialised countries – made the first binding commitment under international law to endeavour to restrict global warming to significantly less than 2 °C compared with the pre-industrial level. Moreover, the contracting parties shall pursue efforts to limit the temperature increase to 1.5 °C.

Climate adaptation and sustainable development: One of the long-term targets in the Paris Agreement is a decision by the contracting parties to increase the ability to adapt to the adverse impacts of climate change, and to foster low greenhouse gas emissions development in harmony with combating poverty and reliable food production.

Transformative climate financing: Flows of finance are to be consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

Greenhouse gas neutrality: In order to stay below the 2 °C cap, the agreement defines the target of achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century. De facto, this means phasing out fossil fuels.

Regular evaluation of the climate action targets: As the Nationally Determined Contributions (NDCs) agreed by the states are not yet compatible with the 2 °C cap, the states must submit new Climate Action Plans every five years from 2020 on.

Reporting: For the first time, every country must report on its greenhouse gas emissions under a common transparency system, to ensure that the advances are also implemented in practice.

Support for developing countries: The Agreement contains a promise by industrialised countries to help developing countries take climate action and adapt to climate change. However, it also invites other nations to voluntarily provide support to poorer countries. In addition to this, the community of nations is to help the poorest and most vulnerable countries to overcome climate-change-induced loss and damages that can no longer be avoided.

In Paris, the global community committed to restricting global warming to significantly under 2 °C. The Paris Agreement therefore marks a historic breakthrough in international climate policy. One key prerequisite for the success of Paris was the G7 Summit held in Germany in 2015. There, the leading industrialised countries committed to decarbonising the global economy by the end of this century. Another key was that the USA, historically the greatest cause of climate change, and China, currently the largest emitter of greenhouse gases, submitted their reduction targets for 2025 and 2030 respectively in late 2014, and thus signalled their support for a global agreement (see Info box).

The rapid ratification of the Paris Agreement shows the community of nations' resolve to work together and to foster global climate action without further delay. The Agreement entered into force less than a year after the Paris Climate Conference, on 4 November 2016. That makes it the fastest enactment of an international law agreement of all time. This was made possible by the fact that the threshold defined in advance was reached ahead of schedule: by October 2016, 55 states, which account for over 55 per cent of the current global emissions, had joined the agreement. To date, the agreement has been ratified by over 140 states. Germany, France, Benin, Mexico, Canada and the USA have already submitted long-term decarbonisation strategies.

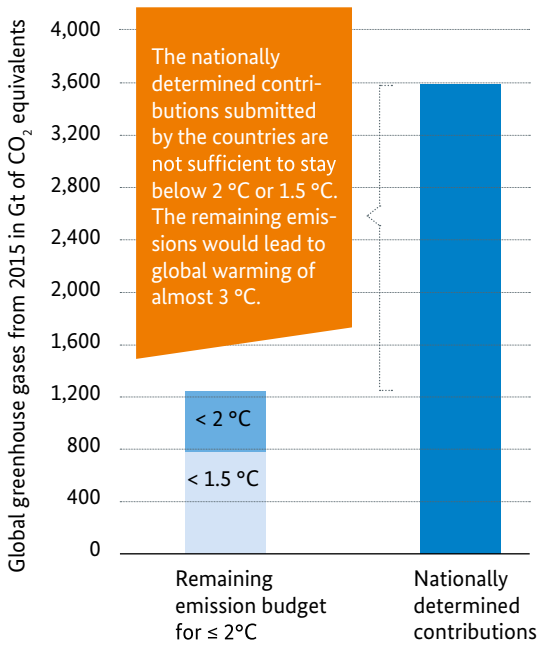
The German G20 presidency in 2017 aims to advance global decarbonisation of the energy sector. The objective is for the G20 members to discuss a common position on long-term decarbonisation and climate resilience. A suitable environment for investment in renewable energy sources, energy efficiency, reduction of subsidies for fossil fuels and the redirection of flows of finance into low-carbon infrastructure is to be created. The highlight of the presidency is the summit of G20 heads of state and government on 7 and 8 July 2017 in Hamburg.

Now, the exact implementation of the Paris targets must be defined. At the climate conference in Marrakesh at the end of 2016, the contracting parties agreed initial concrete planning steps to achieve the ambitious targets. Implementation of the NDCs in the Paris Agreement is particularly important. They represent definitions by the parties of the contribution they are willing to make to global climate action and adaptation in the medium term – most states have set targets for 2030.

To date, only five states have set climate action targets compatible with the 2 °C cap in their national contributions. Even though significant advances have already been made, industrialised countries with unsatisfactory targets, as well as high-emission developing and emerging countries, still have much to do in the years to come (Figure 05).

Germany supports the climate action of other countries with its international climate financing. In 2015, Germany provided developing and emerging countries with 2.7 billion euros from its budget and grant elements in KfW development loans to help them implement the Paris Agreement. Together with the market funds provided by the German Investment and Development Society (DEG) and the German National Development Bank (KfW), the German public sector contribution to climate financing in 2015 totalled 7.4 billion euros. Financed measures for development and implementation of ambitious climate action and adjustment measures range from funding for the largest and most modern solar complex in Ouarzazate, Morocco, through forest and species conservation in Colombia, right up to coastal protection measures in Vietnam.

Figure 05: **Ambition gap**



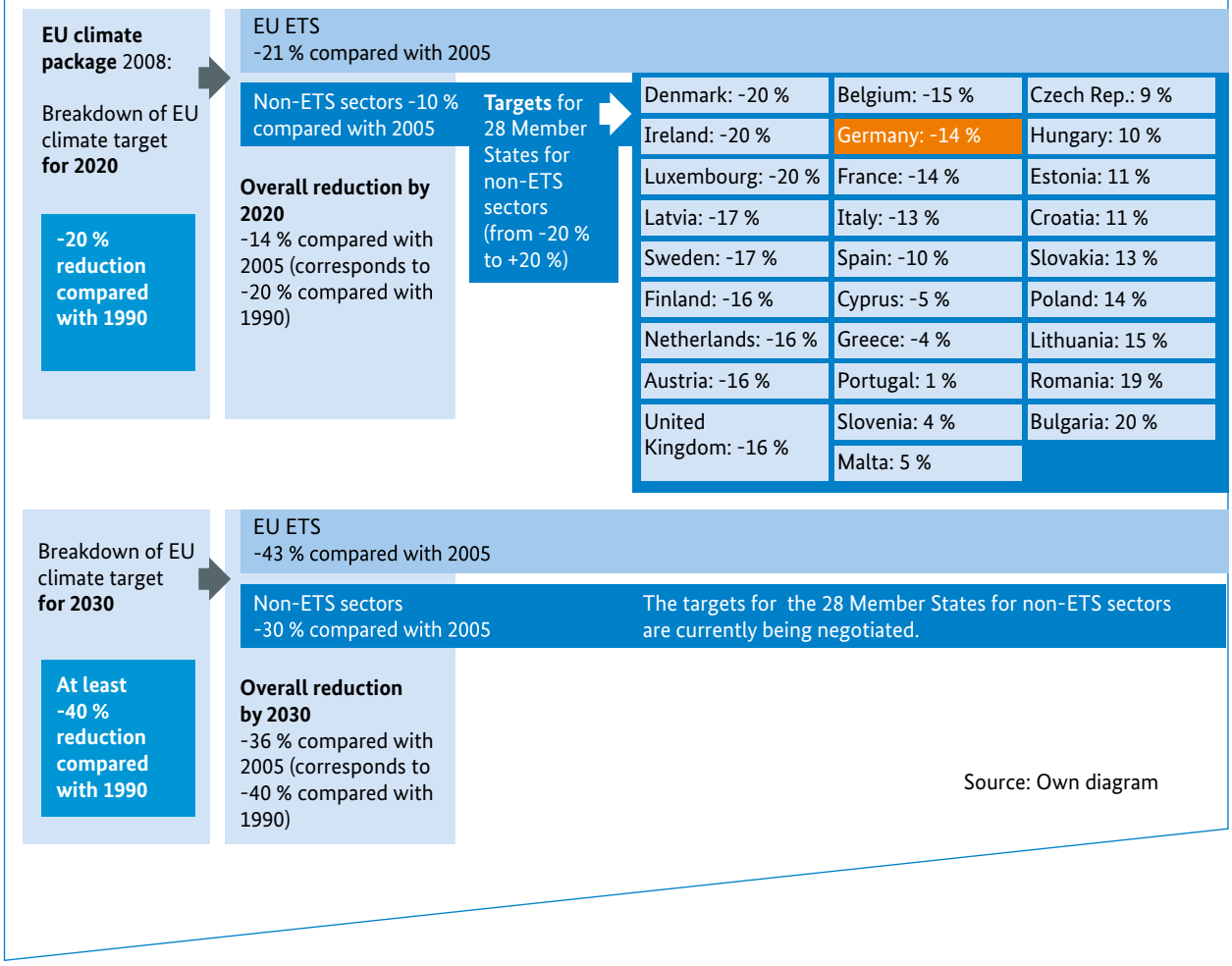
Source: Own diagram based on CAT (2015)

3.2 Implementation in the EU

The European Union is a driving force in the international climate negotiations. As early as March 2015, it submitted a "national contribution" for the Paris Agreement to the United Nations (UN). In it the EU Member States commit to pan-European emission reduction by 2030 of at least 40 per cent compared with 1990. This goal is embedded in the EU's long-term climate action target of reducing EU-wide greenhouse gas emissions by 80 to 95 per cent compared with 1990 by 2050.

Emissions trading (EU-ETS) is an important tool for reaching the EU's 2030 climate action target (Figure 06). The greatest emitters from the energy and industry sector are jointly responsible for roughly 40 per cent of European greenhouse gas emissions. As part of EU-ETS, energy-intensive energy and industrial companies are obliged to purchase tradable rights (allowances) to the

Figure 06: **Breakdown of EU climate target**

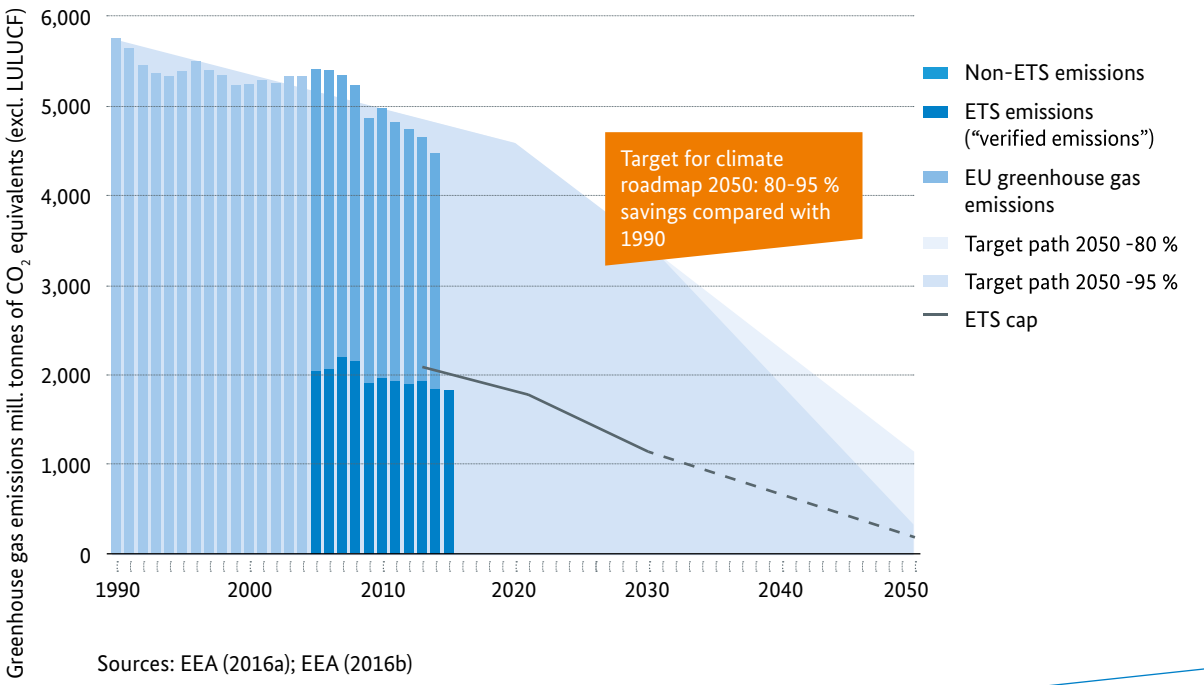


Source: Own diagram

total of the emissions they cause. This is intended to reduce the emissions in these sectors by 21 per cent by 2020, and by 43 per cent by 2030 compared with 2005. However, due to the current certificate surplus, which was caused among other things by the economic and financial crisis, and the resulting lower production output in the EU, the financial incentives for climate action investments are very low. Initial important steps have been taken in reforming the EU-ETS by introducing the market stability reserve (see Glossary).

On the other hand, there is a separate climate action target for the transport, agriculture, waste management and private households (buildings) sectors, as well as for industry and commerce (outside EU-ETS). Together, they cause roughly 60 per cent of EU-wide greenhouse gas emissions. The EU Member States are obliged to reduce their greenhouse gas emissions in these sectors by a total of 30 per cent by 2030 and by ten per cent by 2020 compared with 2005. For the period from 2013 to 2020, the EU already defined binding goals for the individual EU Member States in what is known as the "Effort Sharing Decision". Building on the guidelines of the European Council in October 2014, the EU Commission submitted a proposal in July 2016 ("Effort Sharing Regulation") for the following period 2021–2030. It not only includes national targets (between zero and -40 per cent, see Figure 06) by 2030, but also expanded flexibility options, which are to make it possible to achieve these targets in a fair and cost-effective way. The Commission also proposed a regulation for the land use, land use changes and forestry sector, to integrate

Figure 07: **EU climate roadmap and emission reduction goals**



Sources: EEA (2016a); EEA (2016b)

emissions and CO_2 absorption via these landmasses in the EU climate action framework by 2030.

Figure 07 shows the EU roadmap on the way to a low-emission economy in 2050, including the emission reduction targets within (industry and energy) and outside (transport, agriculture, waste management and private households) the EU-ETS.

The EU climate action target for 2030 is accompanied by a renewable energy and an energy efficiency target. By 2030, renewable energy is to provide at least 27 per cent of the final energy consumption in the EU (20 per cent by 2020). The primary energy consumption is to be reduced by at least 27 per cent by 2030 compared with a development without efficiency measures (20 per cent by 2020). At the end of 2016, the EU commission also proposed legislation to raise the target to 30 per cent.

Until 2020, the Renewable Energy Directive is the EU's key tool for achieving the renewable energy target. It defines how much the individual EU Member States must increase the percentage of final energy consumption from renewables. The per capita economic performance is the benchmark. Similarly, the increase in energy efficiency by 2020 is regulated via the Energy Efficiency Directive. It obliges the Member States to increase efficiency at all levels of the energy sector (generation, supply and consumption). In addition, the building energy efficiency directive requires the Member States to ensure that all new buildings from 2021 are nearly zero energy buildings.

In 2016 and 2017, the EU is revising central instruments for more impactful climate action. In November 2016, the EU Commission submitted initial detailed proposals for revision of the renewable energy, energy efficiency and building efficiency directives. To achieve the renewable energy target, new regulations are to be defined, including regulations for cost-efficient and market-oriented support schemes.

Another measure proposed is an obligation for European fuel providers to prove a rising proportion of renewable energy sources and low-CO_2 fuels (6.8 per cent by 2030). In energy efficiency, the EU Commission announced a new financing initiative ("Smart Finance for Smart Buildings") to help reach the proposed 30 per cent target by 2030, which is intended to mobilise increasing levels of private investments in energy efficiency.

3.3 Implementation in Germany

Political targets

The Federal Government has set itself climate action targets far above the EU average. As the EU Member State with the largest population and the strongest economy, Germany plays a key role in implementing the EU climate action target.

Germany's climate policy pursues long-term goals and planning. The 2010 Energy Concept and the Climate Action Plan 2050 passed in 2016 set targets and interim targets for reducing greenhouse gas emissions, expanding renewable energy and energy efficiency by 2050.

Accordingly,

- by 2050, greenhouse gas emissions are to be reduced by at least 80 to 95 per cent compared with 1990 (by 2020, emissions are to decrease at least 40 per cent, at least 55 per cent by 2030 and at least 70 per cent by 2040),
- renewable energy is to increase to 60 per cent of final energy consumption by 2050 (30 per cent by 2030, 45 per cent by 2040),
- and primary energy consumption is to be reduced by 50 per cent by 2050 compared with 2008 (20 per cent by 2020).

Figure 08 shows an overview of the targets set.

Policy measures

The trinity of "Requirements-Support-Information" is intended to achieve the above targets. The range of instruments and measures is based on laws and ordinances, as well as support programmes, information and communication measures.

Requirements – Examples of central legal regulations related to climate action are the Renewable Energy Heat Act and the Energy Savings Act as well as the regulations on the EU emissions trading and the Federal Immission Control Act.

Support – The Renewable Energy Sources Act has increased competitiveness of renewable technologies. Financial, market-based and fiscal incentives supplement the laws and regulations. This includes the competitive tenders for electricity efficiency rooted in the National Action Plan on Energy Efficiency (NAPE), the KfW support programmes for energy-efficient construction and refurbishment and the support programmes of the National Climate Initiative (NKI). In the 2014 to 2020 funding period, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is also contributing to the European Social Fund with the "Promoting vocational training for sustainable development. On key green competences for climate and resource-friendly action at work (BBNE)" programme designed for this purpose.

Figure 08: **Overview of energy and climate action targets of the Federal Government by 2050**

	2015	2016	2020	2030	2040	2050
Greenhouse gas emissions						
Greenhouse gas emissions compared with 1990	-27.9 %	-27.6* %	At least -40 %	At least -55 %	At least -70 %	-80 to -95 %
Growth in percentage of energy consumption from renewable energies						
Percentage of gross final energy consumption	14.8 %		18 %	30 %	45 %	60 %
Percentage of gross electricity consumption	31.5 %	31.7 %	At least 35 %	At least 50 % EEG 2025: 40 to 45 %	At least 65 % EEG 2035: 55 to 60 %	At least 80 %
Percentage of heat consumption	13.5 %	13.4 %	14 %			
Percentage of transport sector	5.2 %	5.1 %	10 %**			
Reductions in energy consumption and increases in energy efficiency						
Primary energy consumption (compared with 2008)	-7.6 %	-6.6 %	-20 %	→	→	-50 %
Final energy productivity (2008–2050)	1.3 % p.a. (2008–2015)	2.1 % p.a. (2008–2050)				
Gross energy consumption (compared with 2008)	-3.8 %	-4.1 %	-10 %	→	→	-25 %
Primary energy requirement for buildings (compared with 2008)	-15.9 %			→	→	-80 %
Heating requirement for buildings (compared with 2008)	-11.1 %		-20 %			
Final energy consumption for transport (compared with 2005)	+1.3 %		-10 %	-15 to -20 %	→	-40 %

*Estimate for 2016 **Target according to EU Directive 2009/28/EG

Sources: BMWi (2016a); AGEE Stat (2017, as of: February 2017); BMWi (2017a, as of: January 2017)

Information – Information campaigns and mandatory labels for climate-friendly products make purchase decisions easier, and can influence company behaviour through demand for climate-friendly products.

In 2015, the Federal Government also invested almost 863 million euros in promoting energy research. That amounted to roughly 40 million euros more than the previous year, and represents a doubling in the last ten years. Almost three quarters of this went towards researching energy efficiency and renewable energy sources. One example of this is the 6th Energy Research Programme, which promotes research and development of innovative technologies for future green power supply. In total, the Federal Government provided roughly 3.5 billion euros for energy research between 2013 and 2016.

Spotlight 2017

Climate Action Plan 2050 – Pointing the way to a climate-neutral Germany

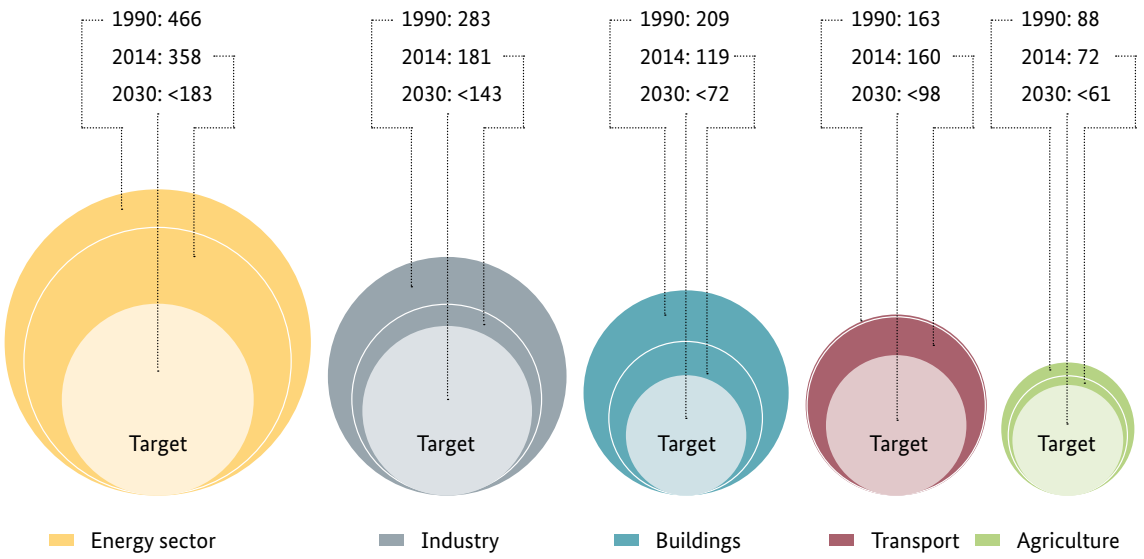
The Climate Action Plan 2050, passed on 14 November 2016, sets the path to a largely greenhouse gas neutral Germany in 2050. For the first time, goals are specified for individual sectors (Figure 09). This provides an orientation for strategic decisions in the years to come, especially for the phase leading up to 2030.

"By setting the course early, we make climate action a driver for the modernisation of our economy." Dr Barbara Hendricks, Federal Environment Minister

To reduce the greenhouse gas emissions in all sectors by at least 55 per cent compared with 1990 by 2030, the Federal Government set target corridors for every sector in the Climate Action Plan, taking specific factors in the individual sectors into consideration. In addition, the Climate Action Plan formulates visions for 2050 and milestones and strategic measures for 2030.

- **Energy sector:** Further expansion of renewable energy and the gradual decrease in fossil power supply are to reduce the emissions in the sector by 61 to 62 per cent compared with 1990 by 2030.
- **Building sector:** With strict standards for new buildings, long-term refurbishment strategies and the gradual reduction in fossil-fuel-based heating systems, greenhouse gas emissions are to be reduced by 66 to 67 per cent in 2030 compared with 1990.
- **Transport:** Alternative drives, especially based on electricity, more local public transportation, railways as well as cycling and walking, and increasing interconnection of means of transport are to reduce emissions in the transport sector by 40 to 42 per cent by 2030.
- **Industry and commerce:** Energy efficiency measures such as using existing waste heat potential and a research and development programme to reduce as yet inevitable industrial process emissions are to contribute to reducing emissions by roughly 50 per cent compared with 1990 by 2030.

Figure 09: **Sector targets in the Climate Action Plan in million tonnes of CO_2 equivalents**



These values are taken from the Climate Action Plan 2050 (Section 5). Values in Section 4 of this brochure are based on current inventory data and may deviate. The field of action "buildings" in the Climate Action Plan comprises the sectors "private households" and "CTS", which are presented individually in this brochure.

Source: Own diagram based on BMUB (2016)

- **Agriculture:** In particular, emissions of nitrous oxide due to excess fertilisation are to be reduced significantly. A total reduction of 31 to 34 per cent compared with 1990 is targeted by 2030.
- **Land use, land use change and forestry:** The sector is not included in the evaluation of target achievement. However, the Climate Action Plan still emphasises measures to maintain and improve the CO_2 storage potential of forests.

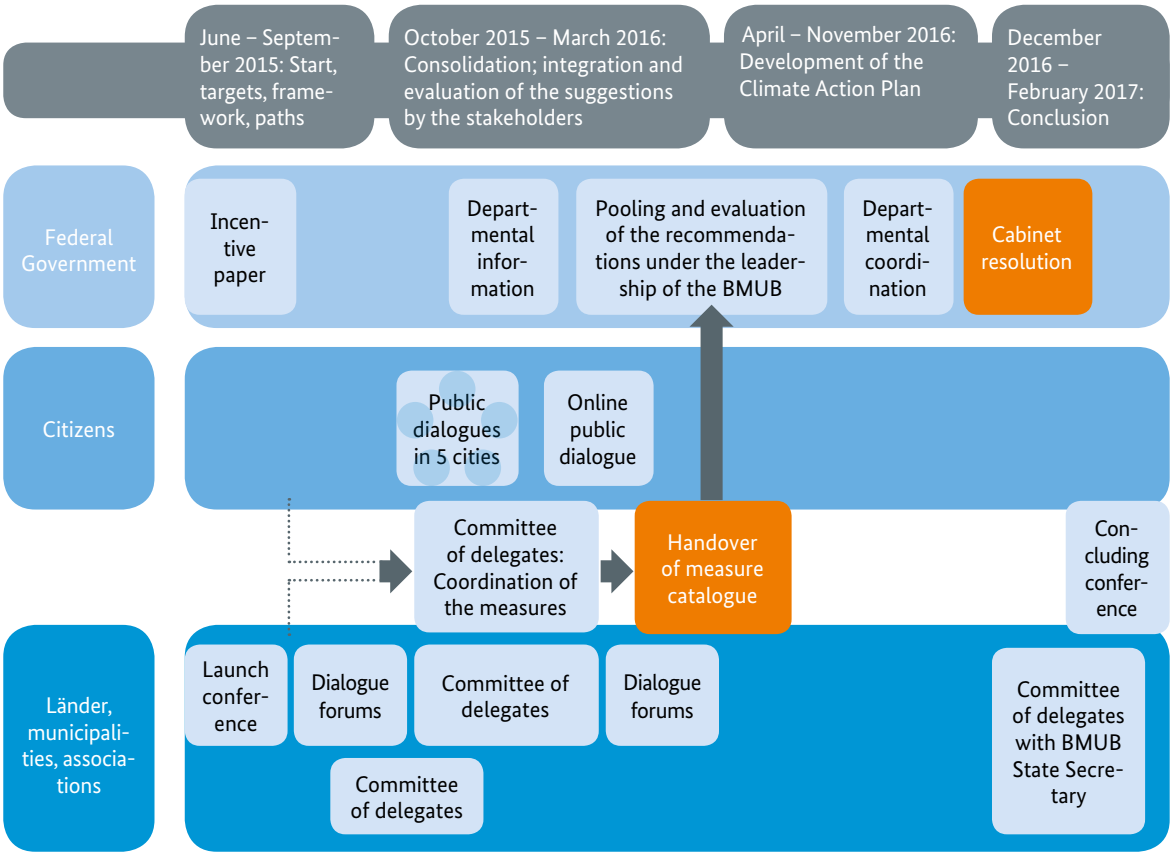
The participation process

The Federal Government has fostered the production of the Climate Action Plan with a broad dialogue process. Over a one-year period, representatives from the Länder (German federal states), municipalities, business associations, community associations and citizens developed proposals for measures in the following areas: the energy sector, buildings, mobility, industry and commerce, agriculture as well as land use and forestry (Figure 10).

Dialogue with Länder, municipalities and associations

In the first round of dialogue, representatives of the Länder, municipalities and associations came together to jointly develop strategic measures for the Climate Action Plan. In the second round of the dialogue forums and in the first delegate committee, the roughly

Figure 10: **Creation of the Climate Action Plan 2050**



Source: Own diagram

400 proposed measures were discussed in greater detail for specific sectors.

Public dialogue

In November 2015, the public dialogue brought together a total of 472 citizens in five German cities, putting forward 77 proposed measures. These were then placed online for public discussion.

Consolidation of dialogue levels

During the participation processes, scientists consolidated the proposals in a set of measures. At the second meeting of the delegate committee, delegates from both dialogues met up to discuss the set of measures.

Result

The participation process came to a close with the third meeting of the delegate committee in March 2016. The catalogue of measures was finalised and handed over to Federal Environment Minister Dr Barbara Hendricks. The catalogue of measures is a foundation for the Climate Action Plan 2050, which was developed by the Federal Government under the leadership of the BMUB.

4. How are emissions in Germany developing?

4.1 Emissions in Germany – past, present and future

Climate measures were instrumental in lowering greenhouse gas emissions by an estimated 27.6 per cent between 1990 and 2016 (and by 27.9 per cent between 1990 and 2015). For example, the greenhouse gas output last year was estimated at 906 million tonnes of CO_2 equivalents compared with 1,251 million tonnes in 1990.

Much of the decrease in emissions in the early 1990s was based on the economic upheaval in former East Germany. Since the mid-1990s, the Federal Government's active climate action policy has had the effect of reducing emissions. Economic fluctuation and heating demand due to the weather affect emission developments. There was an above-average decrease in emissions in 2009 due to the financial crisis. The increase in emissions in 2016 was due in particular to rising road traffic, cooler weather and the additional leap day.

Excess capacities in the fossil-fuel-fired power stations, and associated electricity exports make climate action more difficult. In spite of the successful expansion of renewable energy sources, many emission-intensive power stations remain on the grid. Increasingly, the excess electricity is exported, as the operators of fossil-based power stations (especially those burning lignite) can offer their electricity at comparatively low prices on the European electricity market. Since 2009, this has caused German electricity exports to rise 49 per cent.[12] In addition to the low coal prices on the global

i

Greenhouse gases have different effects on climate change

At 87.9 per cent of the German greenhouse gas output, **carbon dioxide (CO_2)** dominated in 2016. The average lifetime of CO_2 in the atmosphere is 120 years. CO_2 is produced when burning fossil fuels (coal, crude oil and natural gas), among other things, when generating electricity and heat, in private households, in transport and industrial production.

Methane (CH_4) accounts for 6.1 per cent of the greenhouse gases released. The average lifetime of CH_4 in the atmosphere is 9 to 15 years, and therefore far less than CO_2. In spite of this, it makes up a substantial part of the anthropogenic greenhouse effect, as the gas is 25 times as effective as CO_2. CH_4 is produced wherever organic material decomposes anaerobically, that is to say in agriculture and forestry, and in particular in livestock farming. Sewage treatment plants and landfills are other sources.

Nitrous oxide (N_2O) contributes 4.3 per cent to the greenhouse gas emissions. The average lifetime of the gas in the atmosphere is 114 years. While there are only traces of N_2O in the atmosphere, it is 298 times as effective as CO_2 and therefore accounts for a disproportionate share of the anthropogenic greenhouse effect relative to the quantity. It enters the atmosphere due to nitrogen-based fertiliser and livestock farming, as it is produced when micro-organisms decompose compounds containing nitrogen in the soil. This is the case in industrial chemical processes (for example in fertiliser production and the plastic industry).

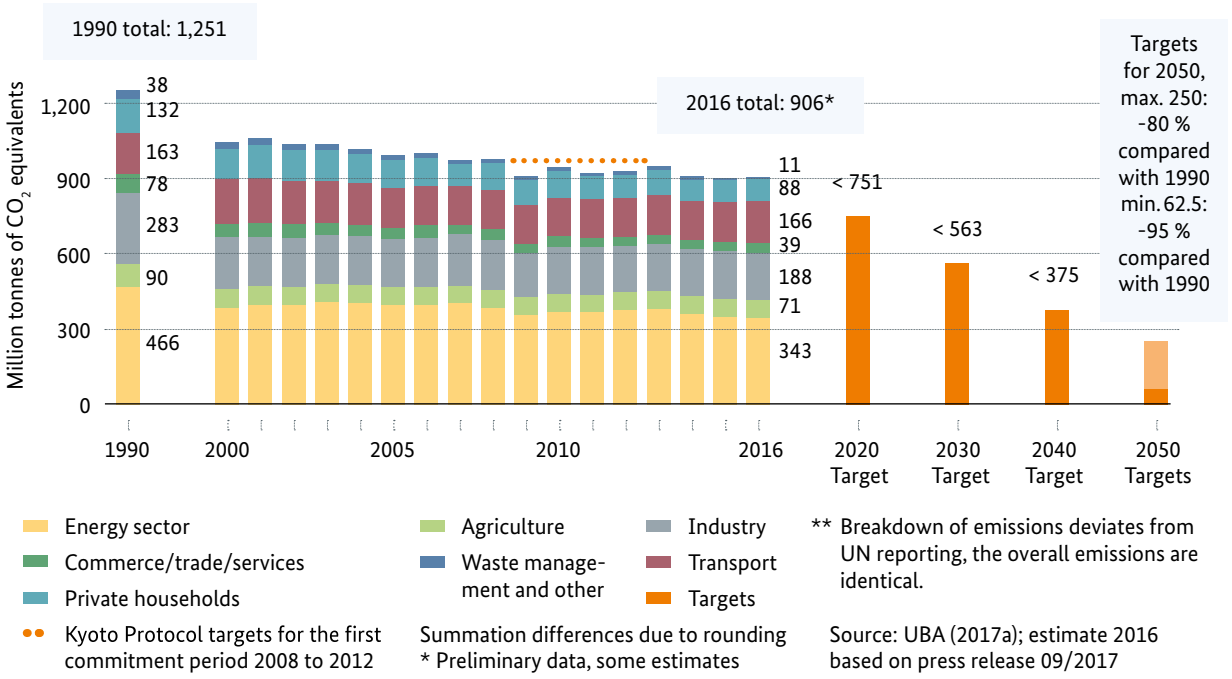
Fluorinated gases (HCFC, CFC, SF_6, NF_3) make up 1.7 per cent of the greenhouse gas emissions in Germany. Compared with methane and nitrous oxide, they stay in the atmosphere even longer, which means they have a major greenhouse effect. By contrast to the other greenhouse gases, fluoro-hydrocarbons (F gases) do not occur in nature. F-gases are only produced for use as propellants, coolants or extinguishing agents, or as part of sound insulation windows (especially SF_6).

market, this is due to the persistently low price for CO_2 as part of emissions trading (EU-ETS). It is currently not sufficient to shift energy production to lower-emission power stations. In addition to this, the phase-out of the relatively low-emission but high-risk nuclear energy has influenced the emission development.

By 2020, German emissions are to decrease by 40 per cent compared with 1990. To reach this goal, the Climate Action Programme 2020 was passed in 2014. Almost 70 per cent of the measures passed in the action programme have now been implemented completely. However, the Federal Government expects a reduction of a maximum of 38 per cent by 2020 if all measures planned are implemented. Depending on more recent estimates, it will make specific adjustments from 2018 on, if necessary.

By the middle of the century, the Federal Government aims to be largely greenhouse gas neutral. Based on the Climate Action Plan 2050, this is to be achieved in the energy, industry, transport, household, commerce/trade/services (CTS), agriculture and waste management sectors, which each account for different proportions of overall emissions (Figure 11). In this brochure, the emissions are reported based on their sector of origin (source principle). In 2015, energy, industry and transport together emitted over 77 per cent of all greenhouse gases in Germany. Figure 12 also shows the emissions by type of gas.

Figure 11: **Emission developments by sector (without LULUCF)****

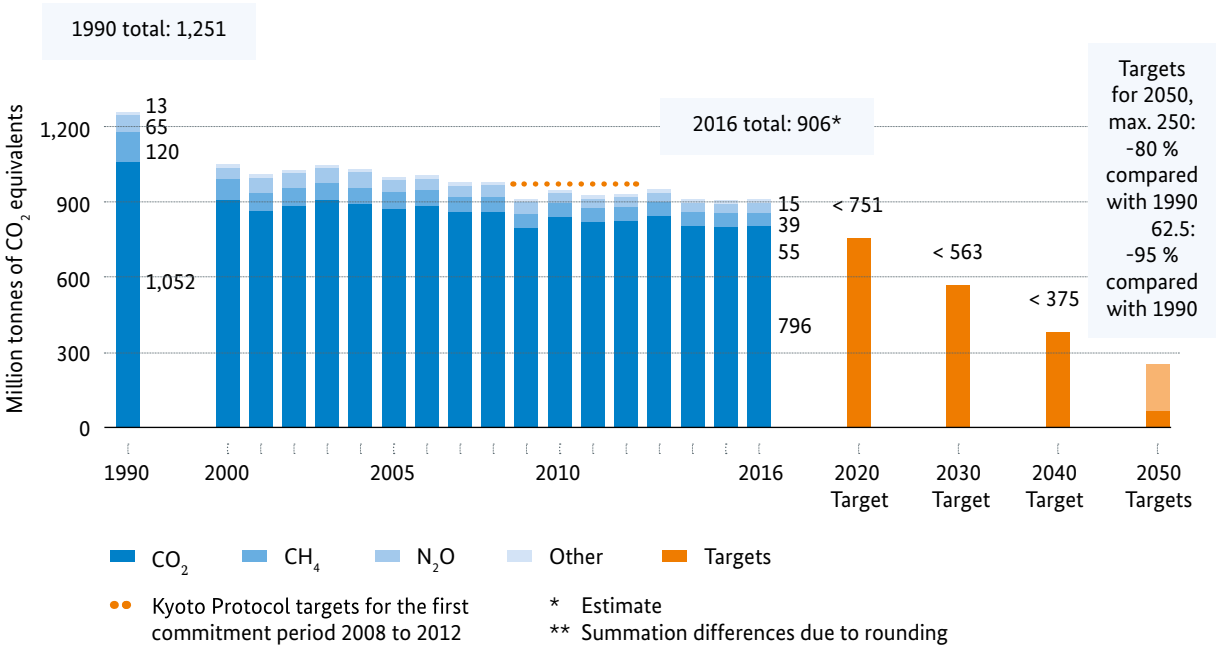


** Breakdown of emissions deviates from UN reporting, the overall emissions are identical.

Summation differences due to rounding
* Preliminary data, some estimates

Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 12: **Emission developments by greenhouse gas****



* Estimate
** Summation differences due to rounding

Source: UBA (2017a); estimate 2016 based on press release 09/2017

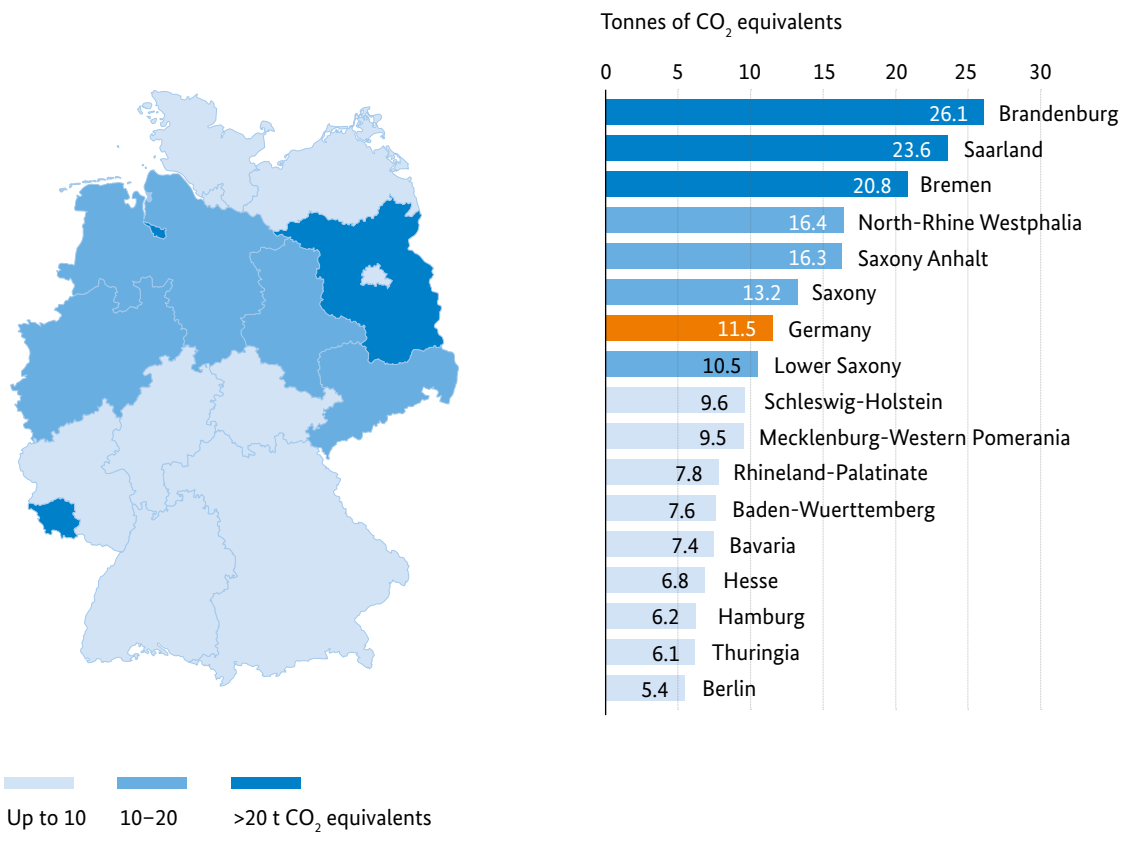
Per capita emissions in Germany vary by region. These differences are determined by the economic structure of a Federal State and the national importance of specific sectors. For example, electricity generation from lignite in the Lausitz contributes to supplying power to all of Germany. This means that the emissions in Brandenburg, at 26.1 tonnes of CO_2 equivalents per capita, are almost twice the German average. Berlin is dominated by the relatively low-emission CTS sector and its per capita emissions (5.4 tonnes of CO_2 equivalents) are almost five times lower than in Brandenburg (Figure 13).

4.2 Energy sector

Emission developments

In 2015 again, the energy sector accounted for the largest share of German greenhouse gas emissions, at 39 per cent. This is in particular due to combustion of fossil fuels in power stations for public supply for provision of electricity and heat. Almost four fifths of the emissions in the energy sector occur when burning lignite or hard coal (Figure 15).[13]

Figure 13: **Breakdown of greenhouse gas emissions per capita by Federal State (2012)**



Source: Own diagram based on Statistical Offices of Federal States (2016)

Sustainable energy policy remains at the heart of German climate policy. Expansion of renewable energy and promotion of energy efficiency on the consumption side have already resulted in significant emission reductions. In this way, greenhouse gas emissions were reduced by an estimated 26.5 per cent by 2016 (Figure 14) compared with 1990. Modernisation of the energy and industry sector in most parts of former East Germany made a significant contribution to this. According to German emissions reporting, the energy sector plays a special role: In accordance with the source principle, all emissions from electricity and heat production are attributed to it, even if the electricity or heat is used in the industry, private households or CTS sector, for example. As a result, reduced energy consumption in these sectors is reflected positively in the climate balance of the energy sector.

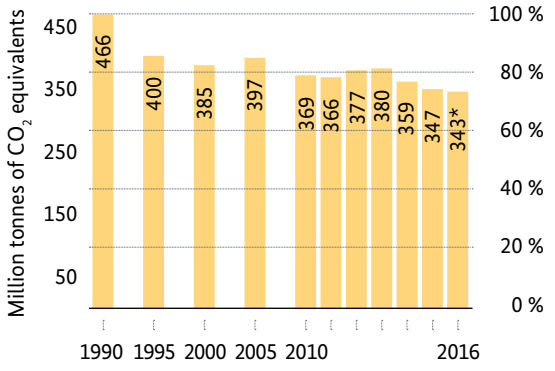
Current political measures

Decarbonisation of the energy supply in Germany by 2050 will be advanced by expanding renewable energy sources and increasing energy efficiency.

In 2016, renewable energy sources dominated the gross electricity consumption in Germany, accounting for 31.7 per cent. Of the total gross power generation based on renewable energy sources in 2016, wind energy contributed 41 per cent, electricity from biomass 24 per cent and photovoltaic systems 20 per cent (Figure 16). The lion's share of the renewables in the electricity mix is due in particular to the Renewable Energy Sources Act (EEG), which has made Germany a pioneer in the energy transition.

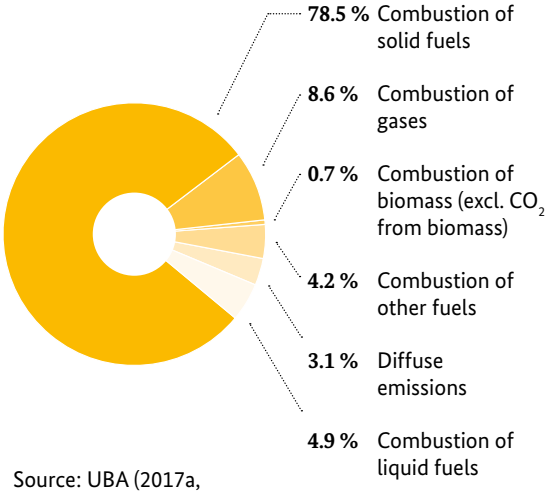
Since the introduction of the EEG in 2000, solar energy has benefited especially from targeted promotion with market-based economic incentives (see Glossary: feed-in tariffs and direct marketing). The technology has a steep learning curve, reducing the (support) costs constantly. For example, solar module prices have been reduced by over 70 per cent in the last ten years.[14] The 2017 EEG amendment also includes the introduction of competitive tenders for onshore and offshore wind energy, photovoltaics (roof-mounted and freestanding) and biomass. This is intended to reduce the costs of renewable energy and comply with the defined expansion target range with a wide variety of stakeholders, including civic energy projects. In 2016, the expansion of renewable energy sources to date reduced greenhouse gas emissions in electricity generation by almost six times as much as in 1990, at over 118 million tonnes of CO_2 equivalents (Figure 17).

Figure 14: **Emission developments in the energy industry**



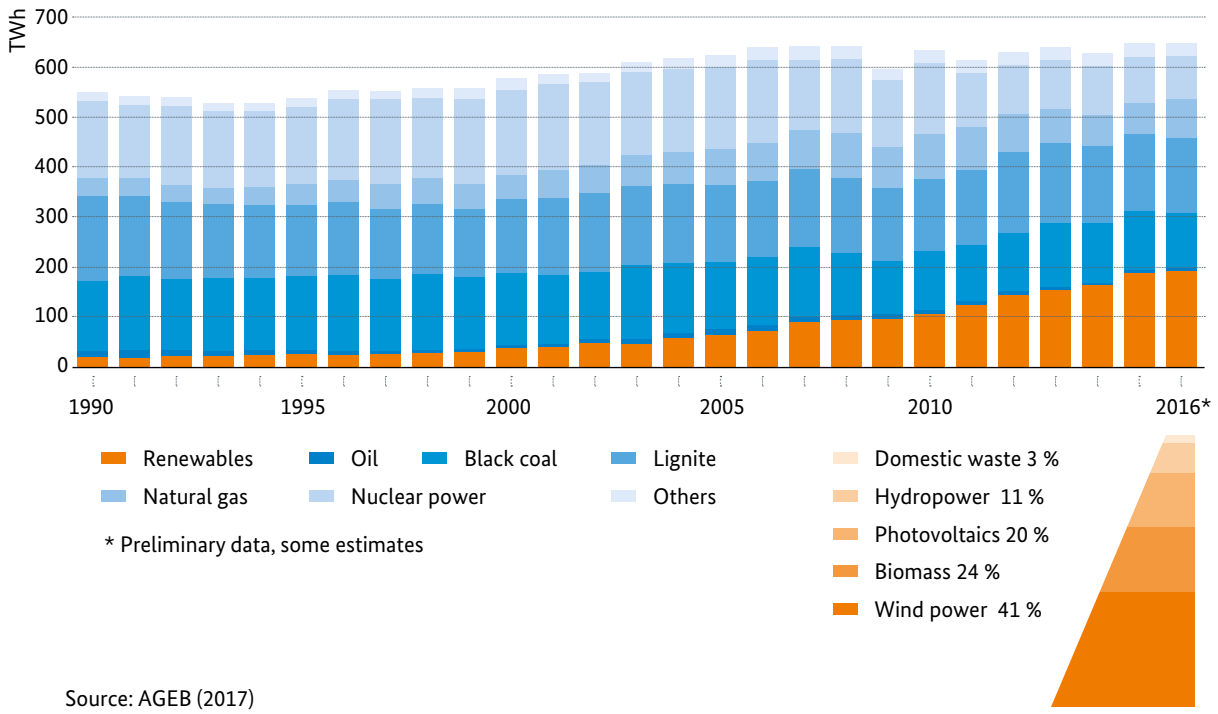
* Estimate
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 15: **Emission sources in the energy industry in 2015 (excluding CO_2 from biomass)**



Source: UBA (2017a, as of: March 2017)

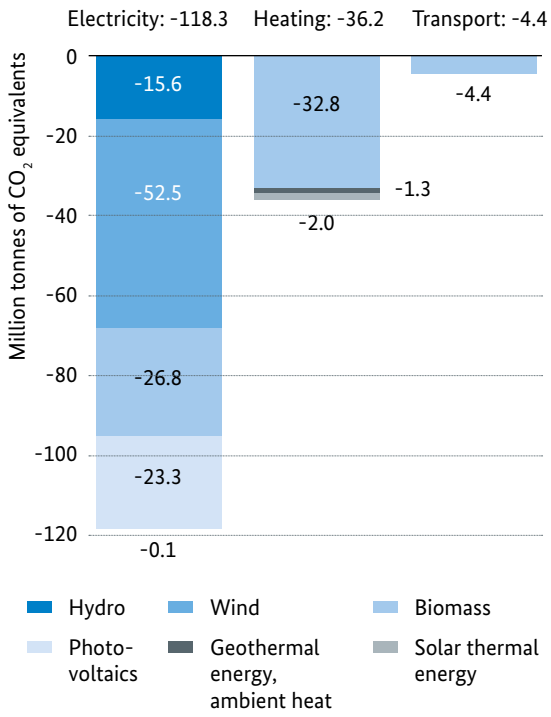
Figure 16: **Development of gross power generation by energy source**



Source: AGEB (2017)

Renewable energy sources are increasingly competitive on the electricity market. The shift in demand to electricity from renewable energy sources is primarily due to cost aspects. The use sequence of power stations to cover electricity demand is determined by their marginal costs, that is to say their variable costs for generating another unit of electricity (merit order). Renewable energy sources are at the very top of the merit order, as generating an additional unit of electricity from wind or solar energy does not incur any additional variable costs (for example for fuels). By setting prices for CO_2 emissions, the EU-ETS also increases the marginal costs for fossil fuel generation taking their external environmental costs into consideration (see Glossary). However, due to the currently low CO_2 price, this has not had the full effect desired. As a result, the Federal Government lobbied at a European level for greater effectiveness through stronger price signals in EU-ETS.

Figure 17: **Avoided greenhouse gases in 2015**



Source: AGEE-Stat (2017, as of: February 2017)

The optimised electricity market 2.0 is the key to a successful energy transition. Wind power and solar electricity depend on the wind strength and/or solar irradiation. The new Electricity Market Act ensures that power supply in Germany remains cost-effective and reliable even with increasing quantities of volatile renewable energy. In addition to this, renewable energy sources are to contribute increasingly to stabilising the electricity grid. To date, it is primarily the conventional power plants that add or remove power to or from the grid at short notice when unforeseen events occur, providing what is known as balancing power. Opening the balancing energy markets for renewable energy sources is intended to integrate wind farm operators, for example, to reduce the use of fossil power plants.

Low-CO_2 gas power stations are a crucial interim technology. While the use of fossil energy from lignite and hard coal is to decrease, modern, high-efficiency and quickly controllable gas power stations can contribute to stabilising the electricity market in the medium term. They can be used flexibly and cause far lower emissions. Increased use of combined heat and power (CHP) plants, which produce electricity and heat simultaneously, is to reduce consumption of fossil fuels.

Transitioning 13 per cent of the emission-intensive lignite capacities to a "safety reserve" with subsequent final decommissioning will save up to 12.5 million tonnes of CO_2 equivalents. That is equivalent to roughly half of the additional contribution of the energy sector specified in Climate Action Plan 2020. On 1 October 2016, the Buschhaus lignite power station was the first to be decommissioned temporarily for four years, and thus transitioned to safety reserve status.

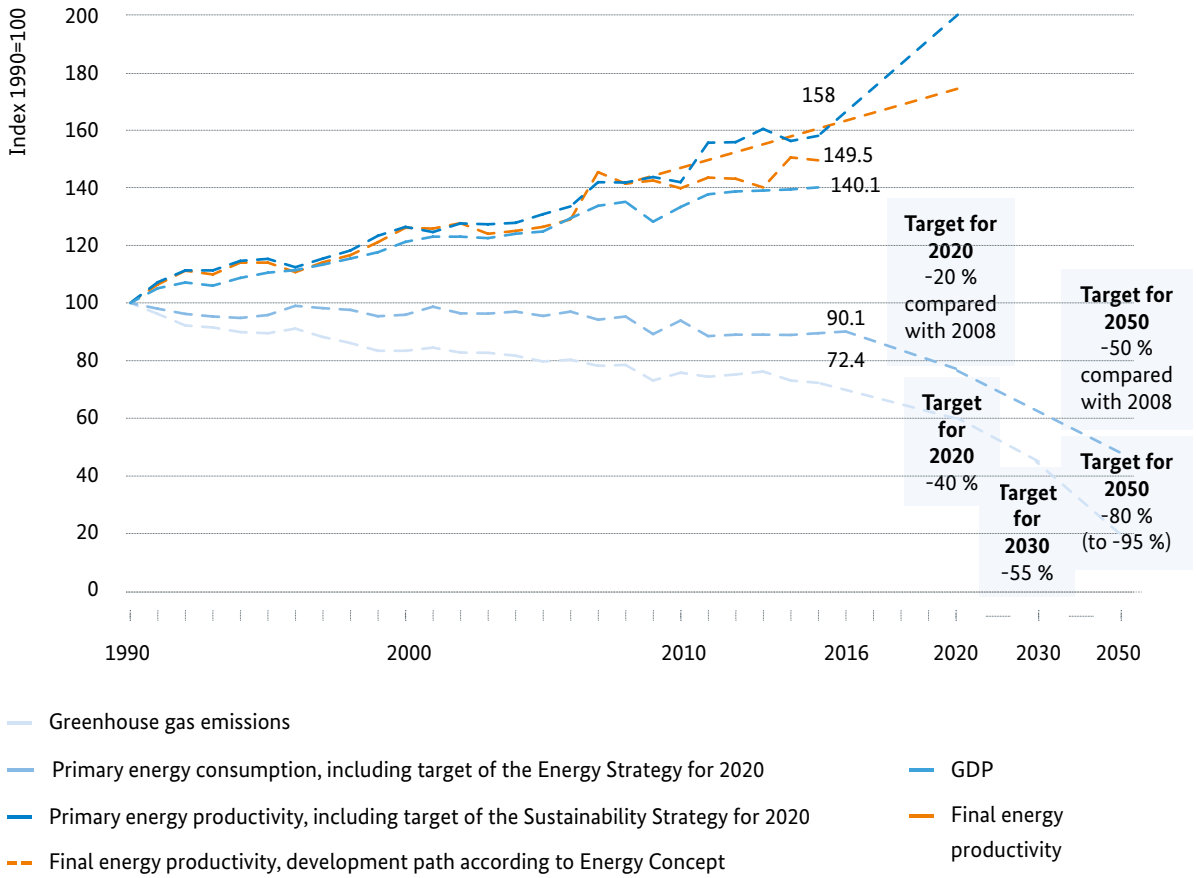
In the long term, use of climate-damaging electricity from coal must be phased out. The percentage of hard coal and lignite in the German electricity mix was reduced by almost nine per cent and eight per cent respectively between 1990 and 2016. In spite of this, electricity from coal still accounts for almost two fifths of gross German power generation. This is due in particular to the long tradition of use of fossil energy sources (hard coal mining in the Ruhrgebiet region and lignite mining in the Rhine and Central German areas). Production of electricity from coal is to be reduced while also avoiding structural breaks in the affected lignite regions and developing new industrial policy perspectives for these regions. To ensure that the energy transition remains a success in future, the sector must turn away from coal-based electricity in a dialogue with the stakeholders involved from business, regions and trade unions.

At the same time, energy efficiency on the demand side must increase further. Energy productivity, that is to say the ratio of gross domestic product (GDP) to primary energy consumption, serves as a measure of the macroeconomic energy efficiency. Decoupling economic growth and energy consumption by increasing energy productivity is the key to sustainable growth. In Germany, the economic output (GDP) has increased over time as the energy required (primary energy consumption) decreased (Figure 18). As a result of that, the energy productivity between 1990 and 2016 has increased more than 50 per cent. By 2050, the energy productivity is to increase 2.1 per cent per annum relative to the final energy consumption (see Figure 08).

The Climate Action Plan 2050 highlights the need for an ambitious energy efficiency strategy. With the Energy Efficiency Green Book, the Federal Ministry for Economic Affairs and Energy (BMWi) initiated a discussion on the strategic orientation of the Federal Government's efficiency policy in summer 2016. The basic principle of "Efficiency First" applies for the Federal Government, as this is the only way to sufficiently restrict demand and expand renewable energy sources while saving resources and preserving the environment.

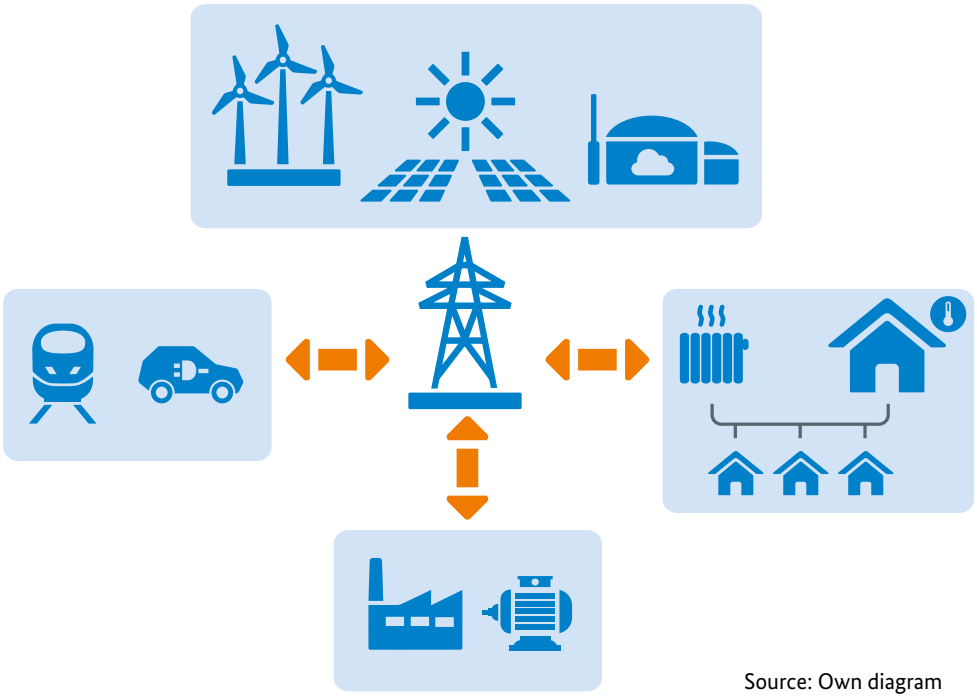
The central energy efficiency measures of the Climate Action Programme and the National National Action Plan on Energy Efficiency (NAPE) have now largely been launched or implemented. As a result, additional savings of roughly 390 to 460 petajoules of primary energy consumption by 2020 can be achieved.[15] This corresponds to approximate greenhouse gas savings of 25 to 30 million tonnes of CO_2 equivalents.

Figure 18: **Decoupling economic growth, greenhouse gas emissions and energy productivity**



Source: Own diagram based on UBA (2017b)

Figure 19: **Sector coupling**



Source: Own diagram

In order to achieve the goal of long-term greenhouse gas neutrality, the industry and transport sector in particular, as well as the building sector must increasingly be supplied with renewable energies (Figure 19). The key is to dovetail the individual economic sectors' energy demand and the supply available optimally. This is referred to as sector coupling. It encompasses all areas of energy conversion and supply, like combustibles and fuels, electricity and heat. The increasing electrification of sectors like transport or heat supply will change demand in the energy sector: The demand for electricity from renewable energy sources will increase, as will the need to increase energy efficiency significantly. However, the increasing dovetailing of the sectors also creates new opportunities. For example, batteries of electric vehicles and (efficiently operated) heat/cold reservoirs can serve as controllable loads in the electricity system.

This allows the volatile electricity generation from wind and solar energy to be stored and fed into the electricity grid on demand or used for heat provision. Alternatively, short-term surplus quantities of electricity can be converted to hydrogen or methane ("Power-to-Gas") and are therefore used in industrial processes or stored in the long term. However, note that conversion can cause significant energy losses. As a result, renewable energy sources should be used directly where technically and economically possible. Stabilisation of the power supply and integration of renewable energy in the industrial value chain contribute to an economical and sustainable power supply.

4.3 Industry

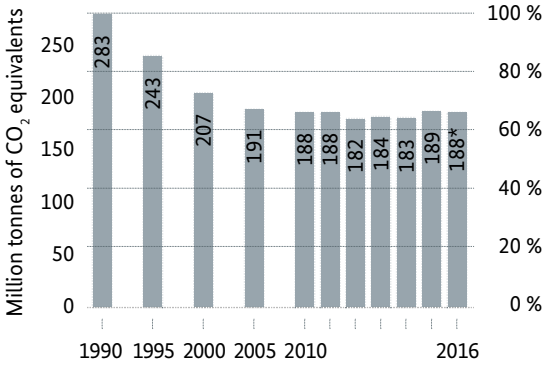
Emission developments

In 2015, industry accounted for just under 21 per cent of German overall emissions. That makes the industry sector the second-largest source of emissions, due in particular to the metal industry (for example iron and steel), manufacturing of mineral products (for example cement) and the chemical industry due to the production of basic chemicals.[16] Roughly two thirds of emissions can be traced back to energy use (industrial furnaces) and almost one third is caused by production processes in the raw materials industry (Figure 21).

Emissions in the industry sector have only decreased slightly in the last 15 years, with the exception of fluctuations due to the economy (Figure 20). Emissions reached an interim high in 2007. Among other things, this was due to economic developments in energy-intensive industry. In turn, the emissions decreased relatively sharply in 2009, as the demand for products from energy-intensive industry dropped temporarily due to the economic crisis. An inverse development can also be observed within the industry sector: refineries, the chemical industry and the mineral-processing industry reported emission decreases again. In paper, iron and steel as well as the non-ferrous metal industry, emissions increased again in 2015 due to deteriorations in efficiency and due to an increase in aluminium manufacturing in the non-ferrous metal industry.

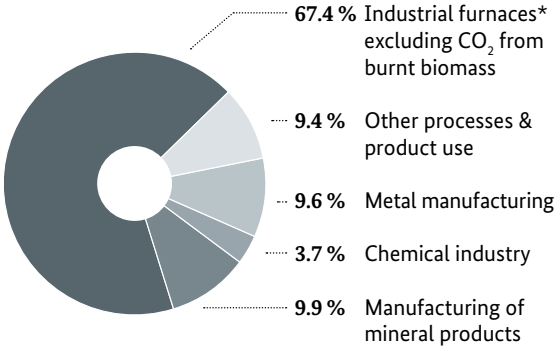
In addition to direct greenhouse gas emissions, there are emissions due to sourcing of third-party electricity and district heating, balanced in the energy sector based on the source principle. Together with the energy produced and consumed internally by the industry sector, this results in the final energy consumption broken down in Figure 22. Accordingly, energy savings in the industry have a positive effect on the emission balance in the energy industry.[17]

Figure 20: **Emission developments in industry**



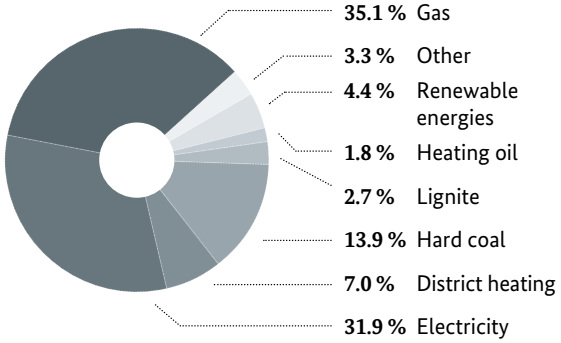
* Estimate
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 21: **Emission sources in industry in 2015**



Source: UBA (2017a, as of: March 2017)
* Combustion processes, for example from firing rotary kilns

Figure 22: **Final energy consumption in industry**



Source: BMWi (2016b, as of: July 2016)

Current political measures

In the Climate Action Plan 2050, the Federal Government decided to roughly halve the emissions reported in the industry sector by 2030 compared with 1990. Among other things, this is to be achieved by making savings in energy use and investments in more efficient and innovative production processes. Production plants in industry, especially in the high-emission raw materials industries, generally have service lives of several decades. That means that timely action is required to avoid capital depreciation and lock-in effects, and achieve emission reductions in energy use and production processes.[18]

Innovative processes and technologies can reduce the useful energy demand in industry. More industrial waste heat is to be used in future, by using residual waste heat in residential areas and in industry in a wide range of ways, for example by feeding it into local and district heating networks and converting it to electricity. Renewable energy sources can also help meet the remaining energy demand in industry and reduce emissions further.

Cost-efficient promotion of combined heat and power

In low-CO_2 combined heat and power (CHP) generation, heat produced when generating electricity or through industrial processes is used as thermal energy. CHP has been supported in Germany since 2002. To ensure that this highly efficient and climate-friendly technology will continue to play an important role, the support level is to be determined via tenders in future. This will help focus on particularly effcient projects and can harness further cost-reduction potential if there is sufficient competition.[19]

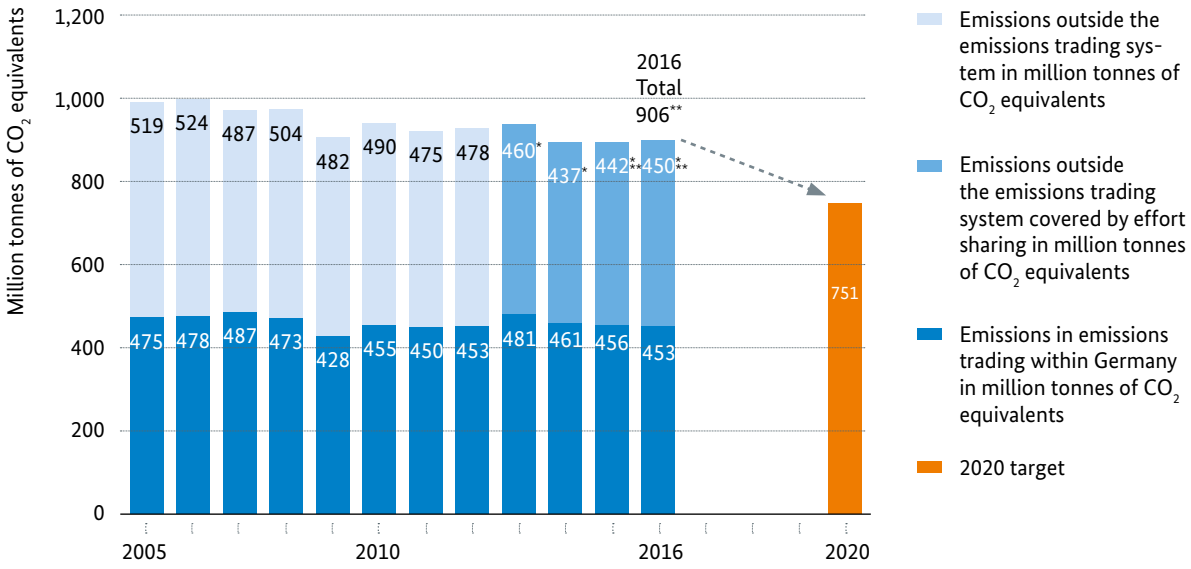
Example of sector coupling in industry: “Power-to-X”

Sector coupling is extremely important for emission savings in industry. For example, the Copernicus Project “Power-to-X” supported by the Federal Ministry of Education and Research focuses on increased use of renewable energy sources in the industry sector, by putting them into flexible interim storage in basic chemicals or as heat for industrial production. The aim is to minimise energy conversion losses and permit flexible load profiles.

Emission reductions in production processes are particularly challenging but there are several options. Some particularly high-emission processes, for example in lime or cement production, could be replaced by new technologies and processes. High-emission raw materials must be used more efficiently along the value chain, as increased material efficiency can make a vital contribution to climate action. This is because of the significant quantities of greenhouse gases released in some cases during mining, transportation, preparation, use in production, use in goods and commodities and disposal and recycling of raw materials. To restrict these emissions, the raw material and material efficiency can also be increased by cross-sector dovetailing of material flows: Slag from iron and metal production can be used for building materials in the construction sector, for example. Innovations in materials science can also replace high-emission materials. In the long term, CO_2 emissions could be reduced via further use (Carbon Capture and Utilisation; CCU) or, if otherwise inevitable, stored geologically (Carbon Capture and Storage; CCS), provided the risks involved are minimised and the CO_2 cannot be stored permanently.

Requirements: Industry must actively contribute to reaching the reduction goals. As in the energy sector, industrial companies subject to emissions trading as

Figure 23: **Emission developments inside and outside the emissions trading system**



* 2013-2016 difference to the sum due to emissions outside emissions trading and effort sharing

** Shares of effort sharing 2015 and 2016 as well as total emissions 2016 based on estimation

Source: EEA (2016b); UBA (2017a); DEHSt (2017)

part of EU-ETS, which covers roughly half of all German emissions (Figure 23), must report on their greenhouse gas emissions and submit corresponding allowances. With a sufficiently high CO_2 price, this creates incentives for greenhouse gas reductions in the industry sector. Outside the EU-ETS, companies from energy-intensive industries benefit from legal exemptions to restrict their energy costs. Reductions or compensation from the Renewable Energy Sources Act (EEG) and CHP levies, energy and electricity taxes and grid charges are intended to keep Germany attractive as an economic location even for energy-intensive industries. This is intended to avoid carbon leakage, that is to say transferring production and emissions overseas. The reduction of the EEG levy, which finances the integration of renewable energy sources, is the most prominent example of this. The costs are largely passed on to private consumers and medium-sized companies. The peak adjustment, which partially reimburses energy-intensive companies from the manufacturing industry for the electricity and energy taxes paid if the producing company as a whole fulfils requirements for energy-intensiveness developments, is another exception.

At a European level, energy audits or the introduction of certified energy management systems for large companies are mandatory. This was implemented in Germany in the amendment of the Energy Services Act. In addition, there are regulations in the industry sector like use bans, to reduce emissions of particularly climate-damaging fluorinated greenhouse gases (F-gases) by 2030 by 70 per cent compared with 1990.

Support: The Federal Government provides funding for climate action measures in industry. The KfW support programmes and other German Government

funding guidelines provide incentives for investments in higher energy productivity and increased use of renewable energy. The funding is also used to reduce financial obstacles, such as long payback times. Since 2016, the competitive electricity efficiency tender ("STEPup!") has served to harness additional reduction potential in companies. It motivates companies to take electricity efficiency measures with good cost-benefit ratios, but longer payback times (three years and more). Expansion to the heating sector is to be considered in future.

As part of the "EnEff:Industrie" research initiative, energy-efficient, innovative concepts, processes, methods and technologies are developed and optimised for industrial and commercial applications. The "Research, development and market launch programme to minimise industrial process emissions" is being developed by the Federal Government as a central measure of the Climate Action Plan for industry. Furthermore, the German Research Ministry already supports innovative research and development projects in the CO_2 use area as part of the "CO_2Plus" measure.

With the German Resource Efficiency Programme (currently: ProgRess II), the Federal Government also promotes a climate-friendly and environmentally friendly resource use along the entire value chain.

The term "industry 4.0" was coined in the context of the Federal Government's high-tech strategy. It describes the digital networking of economic areas in order to optimise logistics and production processes. Among other things, products can be aligned to customer requirements and resources can be saved.

Information: Companies receive better advice to maximise potential savings. Especially in the area of commercial and industrial use of energy and resources, the available information on high-efficiency technologies is growing steadily. However, to date, companies have not used this knowledge sufficiently. The Federal Government therefore aims to accelerate the exchange and application of knowledge. One focus is on qualifying employees in small and medium-sized companies (SMEs). Increasing networking of companies with innovative projects and initiatives is to help eliminate non-financial obstacles like these. Examples of this include the "Learning Energy Efficiency Networks" (LEEN) in the National Climate Initiative (NKI) and, currently, the "Energy Efficiency Networks Initiative" of NAPE.

"Every company that participates in a LEEN network reduces its CO_2 emissions on average by 1,000 tonnes after three to four years, and reduces its energy costs twice as fast as average German companies." Rita Schwarzelühr-Sutter, Parliamentary State Secretary in the BMUB

These initiatives are to form roughly 500 networks by 2020, which will set and reach specific energy-saving targets independently. At a corporate level, the implementation of energy and environmental management systems has been advanced for many years. In order to enhance forwarding and provision of information on resource-saving technologies to SMEs, the VDI Resource Efficiency Centre has been charged with expanding corporate advice services for economical use of natural resources since 2009.

4.4 Transport

Emission developments

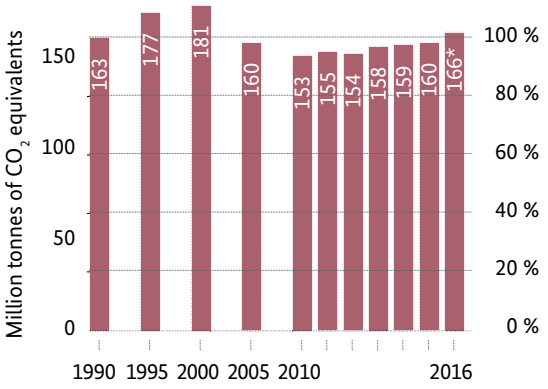
In 2015, the transport sector accounted for 17.7 per cent of greenhouse gas emissions. That makes transport the third-largest cause of emissions in Germany. Of all emissions in the transport sector, 96 per cent result from road traffic. Emissions from railway fuel combustion (for diesel locomotives), waterways and in domestic air traffic are also measured (Figure 25). The electricity used in rail and road transport is included in the energy sector due to the source principle. If we only consider final energy consumption, the transport sector is actually first, at 30 per cent.[20] This is due in particular to the high petroleum consumption (Figure 26). This dependency is also shown clearly based on the passenger car fleet: as of 1 January 2017, 98.4 per cent of passenger cars registered in Germany had combustion engines.[21]

The energy consumption of transport in Germany has more than tripled since 1960.

While only relatively minor advances have been made in recent years in reducing the CO_2 emissions per vehicle kilometre, the climate efficiency of passenger cars has already been improved significantly. Also, in 2016, emissions of 4.4. million tonnes of CO_2 equivalents were avoided by using biofuels in the transport sector. Compared with 1990, the overall emissions in the transport sector only decreased minimally by a little more than two per cent and are stagnating at the level of 2005 (Figure 24). Since 2012, there has even been a slight increase in transport emissions by almost four per cent, which can be traced back to the increasing traffic.

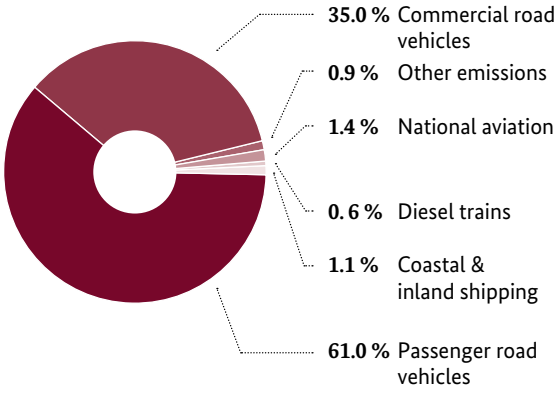
The different means of transport vary significantly in climate efficiency (Figure 27). Per person kilometre, a passenger car causes three to four times higher emissions than a long-distance train or coach in relation to the respective average use. Flying is even five to six times more harmful to the climate.

Figure 24: **Emission developments in the transport sector**



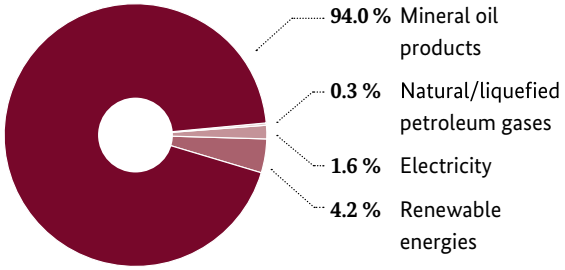
* Estimate
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 25: **Emission sources in the transport sector in 2015 (excluding CO_2 from biofuels)**



Source: UBA (2017a, as of: March 2017)

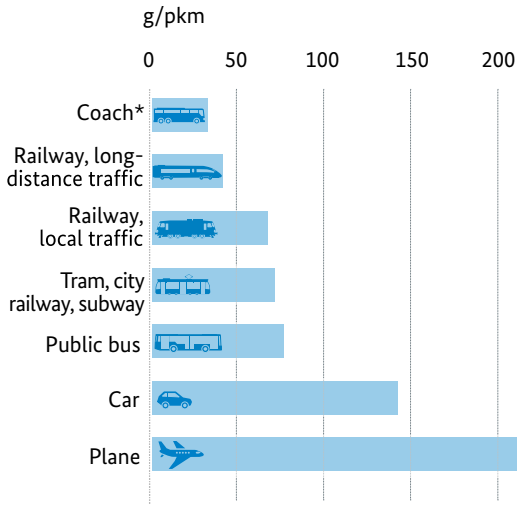
Figure 26: **Structure of final energy use in transport 2015***



* Preliminary data
Source: AGEB (2016)

Figure 27: **Average emissions in passenger transport**

Greenhouse gases as CO_2 equivalents
Base year 2014



*Long-distance bus service and coach trips
Source: UBA (2016a)

Current political measures

By 2020, the emissions in the transport sector will decrease by approximately one per cent compared with 1990 according to current estimates. Savings of six per cent would only be possible if the Climate Action Programme 2020 and NAPE are implemented in full. With the Climate Action Plan 2050, the Federal Government decided to reduce transport emissions by 40 to 42 per cent compared with 1990 by 2030. Among other things, the Federal Government is concentrating on increased energy efficiency of passenger cars, alternative drives and fuels, a shift to environmentally friendly means of transport as well as town and traffic planning that avoids traffic.

Passenger car emissions must also decrease further in the future to restrict the climate impacts of the road traffic that is likely to continue to increase. Since 1992, European regulations have specified and gradually tightened exhaust limits for passenger cars and light commercial vehicles. From 2012 on, an increasing percentage of the new car fleet produced by each manufacturer must not exceed average emissions of 130 grams CO_2 per kilometre. A target of 95 grams of CO_2 per kilometre on average was also defined for all new cars registered from 2020. For light commercial vehicles, the targets are 175 grams of CO_2 per kilometre (2017) and 147 grams of CO_2 per kilometre (2020). The Federal Government is also pushing to pass CO_2 caps at an EU level for heavy commercial vehicles. In 2016, the EU Commission announced that it would measure heavy goods vehicle (HGV) emissions with a new test procedure for the entire vehicle to determine measures on this basis to minimise the emissions.

The Federal Government is also focusing increasingly on supporting electric mobility. In addition to climate-damaging CO_2 emissions, using electric vehicles also avoids air pollutants which pose health risks. However, electrical vehicles are only as clean as the electricity they run on. To reach the emission targets, more of the electricity used must come from renewable energy sources. However, an analysis by BMUB revealed that electric vehicles already caused significantly lower emissions of greenhouse gases than comparable vehicles with combustion engines in 2015, given the German electricity mix and incorporating the emissions caused by vehicle manufacturing (including batteries).[22] In order to map the overall emissions in the transport sector adequately, the electric mobility emissions incurred for electricity generation in the energy sector must also be incorporated.

By 2020, the Federal Government aims to have one million electric vehicles on German roads. By 2030, the number is to rise to six million. The Federal Government has been promoting electric mobility since 2007. A new Electric Mobility Act was passed in 2014. For example, this allows parking fees to be waived for electric vehicles. However, it allows municipalities in particular to mark parking spaces at charging stations in a legally watertight manner. Since 2016, the nationwide charging infrastructure in Germany has received funding of 300 million euros. From 2020 on, additional support for the automobile industry is to bring the price of a plug-in hybrid (see Glossary) in line with diesel car prices. In addition, manufacturers and the Federal Government are already incentivising

purchases of plug-in hybrids and fully electric vehicles with a purchase bonus for a limited period (environmental bonus). Other examples include the "Electric mobility Showcase" support programme, which pools and promotes Germany's expertise in the fields of electric vehicles, power supply and transport systems in large-scale regional demonstration and pilot projects. The "Renewably Mobile" programme also promotes projects which position electric vehicles as marketable environmental innovations.

Use of renewable energy sources via electrification is also being promoted for heavy goods traffic. Research projects on overhead line HGVs are one example. According to recent calculations, overhead lines on motorways could reduce pollution emissions by up to 95 per cent, provided the electricity comes from renewable energy sources.

"Of all greenhouse gas neutral solutions, electric mobility has the lowest macroeconomic costs." Maria Krautzberger, President of UBA

In addition to this, research into producing gas or liquid fuels like power-to-gas methane or power-to-liquid, produced using electricity from renewable energy sources, is to continue. They can be used in vehicles in which it would be very difficult to fit electric drives – that is to say in particular in air and sea freight.

The expansion of rail transport will permit further emission reductions. For example, targeted investments into the railroad network are to ensure that the forecast growth in rail freight of 43 per cent between 2010 and 2030 is exceeded.

Local public transport – and to an increasing extent cycling – contribute to climate action in cities. The significance of local public transport for low-emission transport can be enhanced by using more electricity. For example, the BMUB promotes the use of hybrid buses. Over short and medium distances, cycling and walking help reduce CO_2 emissions. The Federal Government supports municipalities via the National Climate Initiative (NKI) in helping improve the cycling infrastructure and promotes model projects such as infrastructure measures for bicycle parking with the national "Climate action through cycling" competition. Electric bicycles will play an increasing role. According to current estimates, there are already more than 2.5 million pedelecs and e-bikes on German roads today.[24] In terms of traffic avoidance, urban and zoning aspects, as well as the compact city and region concept will play a role in this. A scheduled, integrated urban development can reduce distance between the apartment and central services (for example working, learning, shopping) and cause a transition to walking and cycling. In 2015, the BMUB described a potential scenario for this in its "New coexistence in cities" programme.

Reduction of subsidies harmful to the climate

Subsidies harmful to the climate drain the public coffers with reduced income and higher costs for eliminating damage to the environment and health in future. Much of the subsidies that are harming the environment in Germany involve the transport sector. As a result, in future, an assessment is to be made of how charges and levies in the transport sector can be restructured gradually and without affecting the traffic, so that choosing the means of transport with the lowest greenhouse gas emissions gives citizens and companies a tangible financial advantage.[23]

Multi-means of transport networking in passenger transport

Intermodal (multi-means of transport) services and new mobility concepts like car-sharing and rental bikes help make passenger transport more climate friendly. This includes reducing barriers to accessing local public transport and better networking of means of transport. For example, the Federal Government promotes the introduction of electronic tickets and linking with digital timetable information. Together with better networking across state and transport association borders, this integration can facilitate low-emission, nationwide travel planning.

Sea and air transport is particularly dependent on fossil fuels. In the foreseeable future, both areas will remain dependent on combustion engines. That is why the Federal Government supports research projects on electricity-based fuels based on a CO_2-neutral power supply. Emission reductions in marine and air transport can also be achieved by changing designs. For marine traffic, the CO_2 emissions from 2018 are to be recorded comprehensively for the first time in a European data tracking system, and from 2019 on, in an international data tracking system by the International Maritime Organization (IMO).

Air traffic has already been part of EU-ETS since 2012. Originally, all flights starting and landing in the EU were to be incorporated; however, until 2016, only inner-European flights were incorporated. In addition to this, the International Civil Aviation Organization (ICAO) agreed on a global market-based measure for international air traffic in October 2016 (Carbon Offsetting and Reduction Scheme for International Aviation; CORSIA). On the basis of the target of carbon-neutral growth for international aviation agreed in the ICAO from 2020, CO_2 emissions which exceed the level of 2020 will be offset under CORSIA from 2021 to 2035. CORSIA starts with an initially voluntary phase, which will transition to a mandatory phase from 2027 on. Currently, 66 ICAO Member States have declared their willingness to participate in CORSIA from the start of the measure. This would compensate roughly 80 per cent of growth of air traffic emissions between 2021 and 2035. Against the background of the ICAO decision on CORSIA, the EU must reconsider the question of incorporating aviation into EU-ETS from 2017.

4.5 Private households

Emission developments

In 2015, private households were responsible for almost ten per cent of the direct greenhouse gas emissions. Compared to the previous year, emissions have risen slightly due to the weather conditions (Figure 28). The emissions in this sector are almost all due to burning fuels to heat buildings and hot water (Figure 29). If we incorporate indirect emissions as well as direct emissions (for example from electricity and heat production from households), this percentage would more than double.[25] Electricity consumption alone accounts for 21 per cent of the final energy consumption of private households (Figure 30).

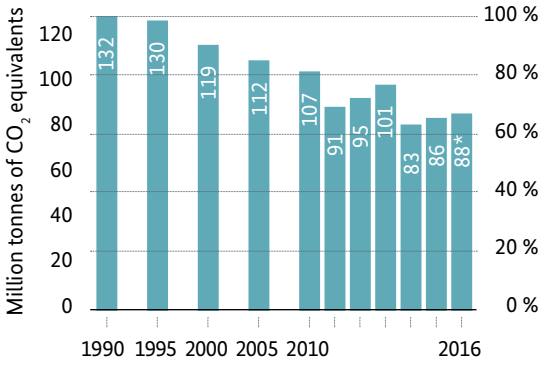
Between 1990 and 2015, private households saved 34.5 per cent of emissions.

Non-residential buildings, that is to say buildings for business, commercial and official purposes, as well as industrial buildings, are largely considered separately in the CTS or industry sector.

As the provision of indoor heating is responsible for roughly two thirds of the greenhouse gas emissions in the buildings sector, weather conditions have a significant influence on the overall emissions in the sector. For example, the remarkable decline in emissions in 2014 was partially due to the hot weather (Figure 28). In 2015, the colder weather compared with the previous year in turn led to an increase in consumption.[26]

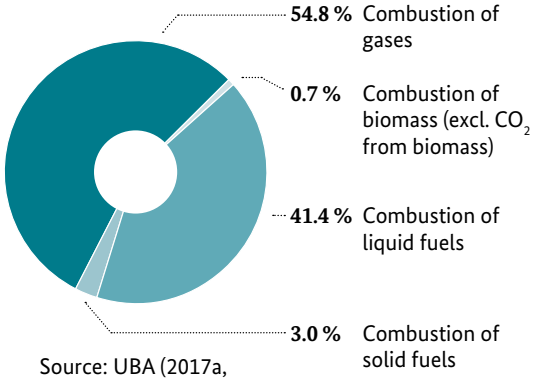
Residential buildings are considered a significant potential for reduction of greenhouse gas emissions. Three quarters of residential buildings were built before the first Thermal Insulation Ordinance of 1979 and therefore have a relatively high energy demand. Substantial refurbishment measures to increase energy efficiency are possible and necessary in many of these buildings.

Figure 28: **Emission developments in households**



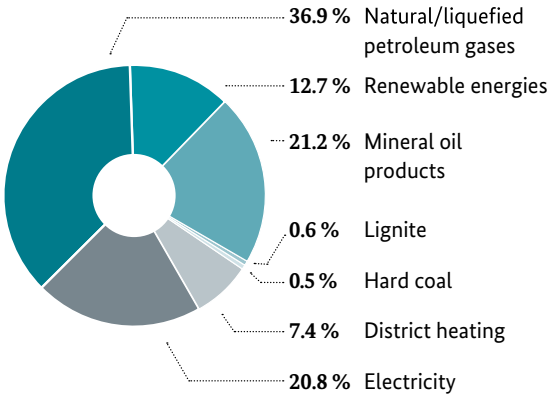
* Estimate
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 29: **Emissions of energy sources in households in 2015 (excluding CO_2 from biomass)**



Source: UBA (2017a, as of: March 2017)

Figure 30: **Structure of final energy consumption in private households 2015***



* Preliminary data
Source: AGEB (2016)

Current political measures

A host of laws and regulations boost climate action in the private household sector. Central regulatory foundations in Germany for more energy efficiency and climate action in the entire building sector include the Energy Savings Act (EnEG), the Energy Savings Ordinance (EnEV), the Renewable Energies Heat Act (EEWärmeG) and the Small Furnace Ordinance. A current goal of the Federal Government is to combine the EnEG, EnEV and EEWärmeG to form a new law. This is intended to create a coordinated set of regulations.

In order to enhance climate action in the building sector, especially with regard to the climate targets set for 2020, the Federal Government has gotten many other measures off the ground in the Climate Action Programme 2020 and National Action Plan on Energy Efficiency (NAPE). The Federal Government is relying in particular on economic incentives for this. Taxation on fuel cells for heating and consumption-dependent heating cost billing for tenants and condominium owners in apartment buildings is designed to encourage economical use of energy. The KfW "Energy-efficient building and refurbishment" programme also offers further financial incentives for urban energy refurbishment and the market incentive programme does so for use of renewable energy sources on the heating and cooling market. The KfW support for energy-related renovations of old buildings is meant to improve the efficiency of the housing stock. Further potential reductions are to be achieved through better consumer information, such as the energy efficiency label for heating systems.

The Federal Government aims to make Germany's building stock virtually climate-neutral by 2050. In order to highlight the necessary steps for using renewable energy and energy efficiency to achieve a virtually climate-neutral building stock, the Federal Government passed the "Building energy efficiency strategy" (ESG) in 2015. With a combination of energy efficiency measures and the use of renewable energy sources, the primary energy demand of buildings is to decrease by roughly 80 per cent compared with 2008 by 2050.

As part of the Climate Action Plan 2050, the ESG will become part of the "Climate-friendly building and living" strategy. It also deals with fundamental aspects of living, including affordability, district and urban development, development of rural areas and the challenges of demographic change.

Example of sector coupling via electrification of the heat supply

Heating in Germany is currently largely based on fossil energy sources like oil and gas. In future, renewable energy sources are to play a greater role here too. In high-efficiency buildings, it makes sense to supply the remaining heat requirements with heat pumps: they are generally run on electricity. They absorb existing heat from the environment (soil, air), condense it and use it to operate the heating system. In energy refurbished buildings, good heat pumps can generate multiple kilowatt hours of heat from one kilowatt hour of electricity. If heat storage tanks are also used, the heating can make electricity demand more flexible, helping to stabilise the energy system. Using heat pumps ("Power-to-Heat" technology) is one way to replace fossil fuels. The more electricity comes from renewable energy, the more successfully this technology contributes to protecting the climate. Advances in energy modernisation of buildings are also needed to use future-proof heating technologies. Moreover, renewable energies can also be used directly for heat supply (for example via solar thermal energy, hybrid systems, CHP) and incorporated in heating networks.

4.6 Commerce, trade and services (CTS)

Emission developments

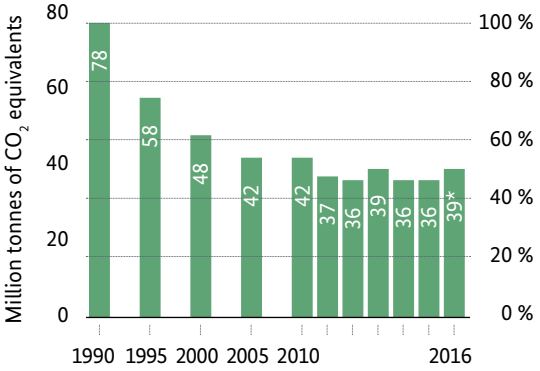
In 2015, the CTS sector contributed almost four per cent to the overall emissions, a relatively low level. However, the sector accounts for almost three times as much of the final energy consumption in Germany at 15 per cent.[27] Roughly half of the final energy consumption is incurred for indoor heating in non-residential buildings like companies, accommodation, bars and restaurants, homes and retail outlets, which are not incorporated in the private household sector (Figures 32 and 33).[28] Building cooling also becomes increasingly relevant for non-residential buildings, as more and more air conditioning systems are in use. Emissions from electricity and district heat generation, for example for cooling and lighting or heating, are also attributed to the energy sector here based on the source principle.

The greenhouse gas emissions in the CTS sector were reduced by almost 54.2 per cent between 1990 and 2015.

The emission reductions in the CTS sector were achieved primarily due to rising energy efficiency. Between 1990 and 2015, they were improved by almost 2.2 per cent per annum on average.[29] This was achieved in particular through improved thermal insulation, increasing automation and process optimisation as well as modernisation of machines and plants. The emission fluctuations shown in Figure 31 are largely due to fluctuating weather conditions – as was the case for private households.

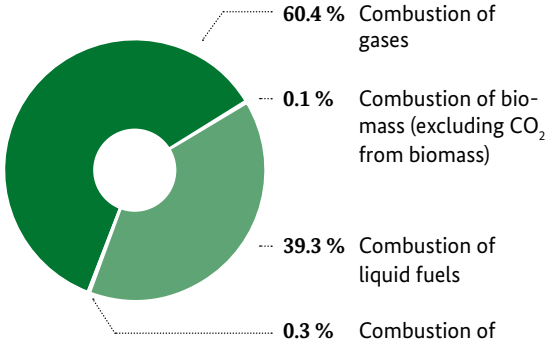
Due to the similar energy consumption structures, energy saving measures in the CTS sector overlap in particular with the private household sector and industry (Figures 30 and 22). The electricity consumption by the CTS sector increased from 24 per cent of final energy consumption in 1990 to 38 per cent in 2015. Due to increasing automation and sector coupling, this trend is likely to continue.

Figure 31: **Emission developments in commerce/trade/services (CTS)**



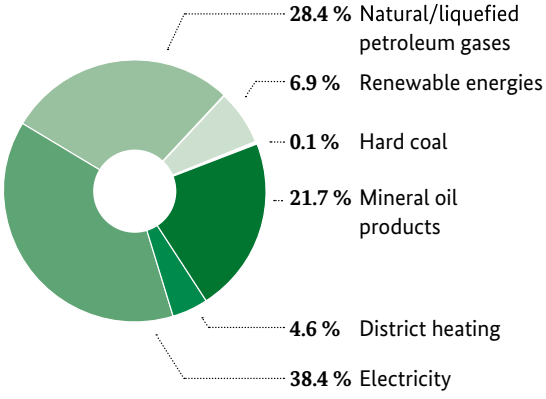
* Estimate
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 32: **Emissions of energy sources in CTS in 2015 (excluding CO_2 from biomass)**



Source: UBA (2017a, as of: March 2017)

Figure 33: **Structure of final energy consumption in CTS 2015***



* Estimate
Source: AGEB (2016)

Current political measures

As in the private households and industry sectors, the Federal Government is also incentivising further increases in investments in energy efficiency and the harnessing of additional greenhouse gas emission reduction potential. For example, BMUB is supporting the German Hotel and Catering Foundation energy saving campaign to achieve this goal. Support programmes aim to promote the use of best available technologies.

The energy consumption of non-residential buildings is to be reduced to one fifth of the consumption in 2008 by 2050.[30] As part of the Building Energy Efficiency strategy, previous savings are to be increased via targeted financial incentives to increase energy efficiency of buildings, regulatory stipulations like the Energy Savings Ordinance and targeted information.

"We want to use the synergies between the goals of 'affordable living and building' and 'climate action'." Dr Barbara Hendricks, Federal Environment Minister

To achieve energy saving potential, the Federal Government also relies on energy consulting and promotion for SMEs, such as the "Medium-size Company Initiative for the Energy Transition and Climate Action". Through the "Energy Consulting Service for Medium-Sized Companies" programme, 17,000 companies from the CTS and industry sector benefited from consultation between 2008 and 2013. Low-interest loans and repayment grants from KfW also offer funding options for new buildings and energy refurbishment of non-residential buildings and individual measures in the CTS sector.[31]

Example of sector coupling via heating networks in the CTS sector

In future, thermal storage will allow excess electricity produced in the summer to be stored in large seasonal heat storage facilities. The heat stored can then be used in the winter months to heat buildings. This storage is particularly suitable near large non-residential buildings, districts or heating networks, as the larger the storage facility, the less heat is lost. Heat pumps can be used for storage.

A low temperature level helps absorb a lot of heat. Good insulation in the building or heating network supplied is very important. However, compared with the current state of the art, the storage volumes must be increased significantly. In this way, high-efficiency heat pumps allow the heat yield per kilowatt hour of electricity to remain high in spite of the storage losses.

4.7 Waste management and circular economy

Emission developments

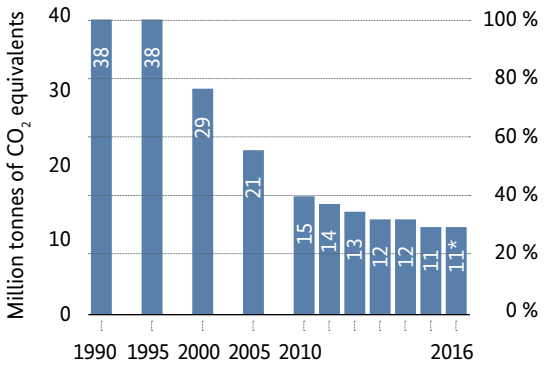
At somewhat more than one per cent, waste management and circular economy once again accounts for a relatively low percentage of the climate-relevant overall emissions in Germany in 2015. In 2015, they totalled 11.2 million tonnes of CO_2 equivalents (Figure 34). This also includes emissions from wastewater treatment. In 2015, emissions from landfill gases and wastewater management together accounted for almost 90 per cent of total emissions in the sector (Figure 35).

Since 1990, the emissions in the sector decreased at an above average level, at 70.5 per cent. This is primarily due to reduced methane emissions caused by the ban on landfilling biodegradable municipal waste. Energy use of waste and increased recycling in particular of glass, paper and cardboard, as well as metal and plastics, facilitated further savings.

Current political measures

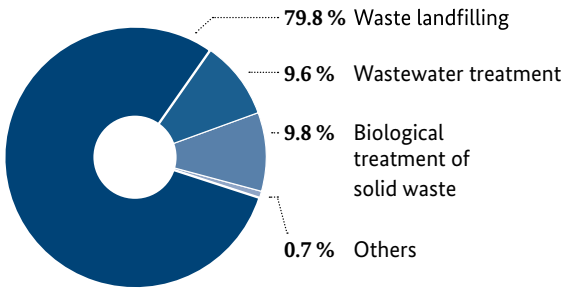
In the years to come, the Federal Government aims to develop waste management and circular economy to a materials flow management system. With leading recovery and recycling rates worldwide in some materials, Germany is already a pioneer in implementing climate- and resource-friendly circular economy. This includes in particular recovering processed raw materials via recycling and using waste to generate electricity and heat. In addition, energy recycling of waste makes a key ecological contribution to saving fossil fuels. In the long term, the Federal Government aims to use the materials and substances in waste for materials and energy, thereby further reducing landfilling of waste. However, landfills will continue to play an essential role for mineral waste.

Figure 34: **Emission developments in waste management and other****



* Estimate
** Excluding credit from recycling and energy generation
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 35: **Emission sources in waste management in 2015 (excl. CO_2 from biomass)**



Source: UBA (2017a, as of: March 2017)

Environmentally friendly disposal of waste electrical equipment

Correct disposal of waste electrical equipment avoids an environmental hazard and allows the reusable materials to be recycled. Since 2016, retailers must accept returns of waste appliances free of charge (Electrical and Electronic Equipment Act). This applies both for stationary and online retail with over 400 square metres of retail space or shipping and warehouse space for electrical appliances. For large appliances, retailers are only obliged to accept the waste device when customers purchase a new appliance that fulfils the same purpose. For small devices like razors or mobile phones, the obligation applies regardless of whether the customer bought them from the retailer or not. Moreover, public sector disposal companies have long been obliged to establish free collecting points for waste electrical equipment. Consumers must return waste electrical equipment in one of these ways.

Today already, more than half of the municipal and production waste is recovered. The recycling rates for construction waste, packaging or batteries are even over 80 per cent.[32]

The amendment of the Packaging and Commercial Waste Regulations aims to bolster recycling, harnessing further reduction potential. In addition to this, secondary raw materials such as secondary aluminium are to be recovered from waste, to reduce the greenhouse gas emissions compared with the use of primary raw materials.

Suitable measures are to be taken to reduce the release of methane emissions from old landfills. The Federal Government already supports the municipalities with funding from the National Climate Initiative (NKI) as part of the Municipal Guideline.

4.8 Agriculture

Emission developments

The percentage of overall emissions from the agricultural sector increased further in 2015 to over eight per cent. Unlike other sectors, the key greenhouse gas emissions are not CO_2 emissions, but in particular methane (CH_4) and nitrous oxide (N_2O) emission, which have extremely strong effects on the climate. Methane emissions are due in particular to dairy farming, as the gas is produced in the digestive tracts of ruminants. In agriculture, N_2O is caused by nitrogen-based fertilisers and animal husbandry. Also, organic soils used for farming emit significant quantities of CO_2, which is attributed to land use in the emission balance, not to agriculture (see Section 4.9).

From 1990 to 2015, greenhouse gas emissions in agriculture were reduced by almost 19 per cent (Figure 36). This is primarily due to the decrease in livestock as a result of the structural change in former East Germany, the environmental requirements of the common EU agricultural policy and improvements in fertiliser management. However, there is a limit to the extent to which emissions in agriculture can be restricted with technical measures, as most are caused by natural processes (Figure 37).

Current political measures

The EU's Common Agricultural Policy (CAP) will contribute increasingly to the Member States' climate action efforts in future. Since 2014, 30 per cent of direct payments to farmers under the CAP are linked to compliance with climate and environmentally friendly farming methods (greening bonus). The CAP also includes specific support programmes for sustainable and environmentally friendly farming and rural development. The "European Agricultural Fund for Rural Development", the second funding cornerstone of the CAP besides the direct payments, supports voluntary agricultural environmental and climate action measures at a state level, among other things.[33]

Ecological farming is another important way to increase sustainability in agriculture. It avoids mineral fertilisers and synthetic chemical pesticides, reducing

the CO_2 emissions per hectare by up to 50 per cent compared with conventional farming. In 2015, roughly 6.5 per cent of agricultural land in Germany was farmed ecologically.[34] The Federal Government has set a target of 20 per cent for the future.

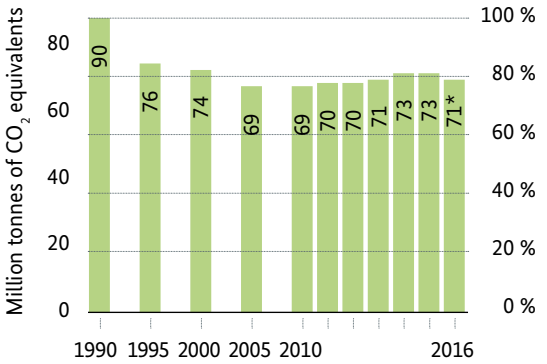
"Last year, organic products with a total value of almost ten billion euros were sold in Germany [...] and ecological production in Germany still has significant growth potential." Christian Schmidt, Federal Minister of Food and Agriculture

The switch to more ecological farming is supported through the second cornerstone of the CAP at state level, as part of support measures in the Joint Task for the "Improvement of Agricultural Structures and Coastal Protection" (GAK). Overall, GAK measures contribute to climate action directly via climate action measures and indirectly via measures to protect the environment and nature and maintain the landscape. The "Federal Programme for Ecological Farming and other Forms of Sustainable Agriculture" also provides 17 million euros annually.

Outside ecological farming, the German Fertiliser Ordinance (DüV), a key part of the action programme for legal implementation of the EU nitrate directive, defines the requirements for good professional fertilisation practice in greater detail. However, surplus nitrogen from excessive use of fertilisers in agricultural soil in Germany remains far too high. The Federal Government has amended the DüV comprehensively. Among other things, it aims to improve the nitrogen use and reduction of excess nitrogen, and in this way to contribute to the further necessary decrease in N_2O emissions. At the end of 2015, the cabinet had reached a decision on the amended version. The DüV and the Fertilisation Act are to be passed in the plenary assembly of the Bundesrat before the end of spring 2017. In spite of this, the EU Commission filed a complaint with the European Court of Justice against Germany at the end of October 2016 on the basis of the old DüV, due to insufficient implementation of DüV.

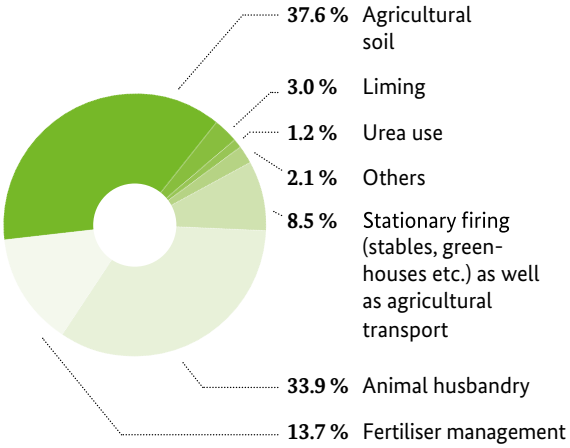
In August 2016, the Federal Government presented the "Integrated Environmental Programme 2030". This was done in the context of the United Nations passing Agenda 2030 for sustainable development. In it, BMUB also proposes targets and measures for agriculture, including greater support for ecological farming, measures for enhancing protection of biodiversity (see core topic box), restriction for factory farms and development of a national nitrogen strategy. Several measures are to be taken to reinforce sustainable consumer behaviour. For example, a second

Figure 36: **Emission developments in agriculture****



* Estimate
** Including agricultural transport
Source: UBA (2017a); estimate 2016 based on press release 09/2017

Figure 37: **Emission sources in agriculture in 2015 (excluding CO_2 from biomass)**



Source: UBA (2017a, as of: March 2017)

price label will inform consumers of the environmental costs of particularly environmentally relevant products and services. Reducing the continued very high meat consumption in Germany, for instance, would be a key contribution to protecting the environment and nature and reducing health risks.

Biodiversity

Species and habitats are increasingly under threat. This means that biodiversity is decreasing worldwide, including in Germany. The existence of almost every third species of animal or plant in Germany is endangered.[35] Besides agriculture, which is frequently not environmentally friendly, there are still too few areas in Germany where nature can develop without human disturbance. In general, the value and use of nature and its ecosystem contributions are not appreciated sufficiently. Accordingly, the "Integrated Environment Programme 2030" includes a public debate on "sustainable agriculture" and the development of the legal framework for soil protection as measures to promote biodiversity. Within the EU, the Federal Government also campaigns for eco-friendly implementation of the common European fisheries policy.

4.9 Land use, land use change and forestry (LULUCF)

Emission developments

The LULUCF sector succeeded in reducing the net emissions by 14.6 million tonnes of CO_2 equivalents in 2015 (Figure 38). It acts as a sink, that is to say as CO_2 storage. Overall, almost 60 million tonnes of CO_2 equivalents were stored in 2015, in particular in forests (96.5 per cent of the sink capacity) and also in wood products (3.5 per cent). Especially sustainable, natural forestry management helps preserve forests as a sink. However, stored CO_2 is released again by intensive agriculture and forestry use, emitting over 45 million tonnes of CO_2 equivalents in 2015. Over half of these emissions were caused by converting grassland into arable land (Figure 39). When permanent grassland is ploughed, far more CO_2 is released, and released faster than can be bound by creating new grassland. Soil-friendly farming methods when cultivating land can reduce discharges of the stored CO_2 emissions. Between 1991 and 2015, the extent of these areas in Germany has already decreased by roughly 12 per cent. Agricultural use of arable land is responsible for another third of these greenhouse gas emissions in this sector.

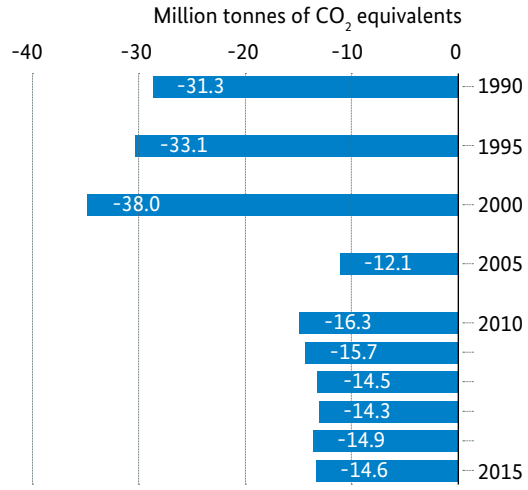
Agricultural soils and forestry store less than half as much greenhouse gas emissions as in 1990. Emissions from the land use, land use change and forestry sector have not been incorporated in assessments on the achievement of national and European climate action targets until now. On one hand, this is due to the fact that balancing these emissions is methodologically more difficult than for other sectors. Also, the storage capacity of soils and vegetation is susceptible to external dangers such as forest fires or insect attacks, which can reduce it unexpectedly. On the other hand, anthropogenic climate action due to forestry work is extremely difficult to distinguish from fluctuations in natural storage effects.

Current political measures

Harnessing the significant potential reductions in the LULUCF sector is part of the Climate Action Programme 2020. Sustainable forestry in harmony with nature and extensive grassland use can reduce the release of stored CO_2. Especially forests rich in species and structure, as well as wet forest areas, offer potential reductions as CO_2 stores. Preservation of permanent grassland is another core element of the action programme. This will mainly be achieved through greening as part of the EU CAP, that is to say linking part of the direct payments to specific climate action and environmental targets. This is also taken into consideration when designing the voluntary agricultural environmental and climate action measures (see Section 4.8).

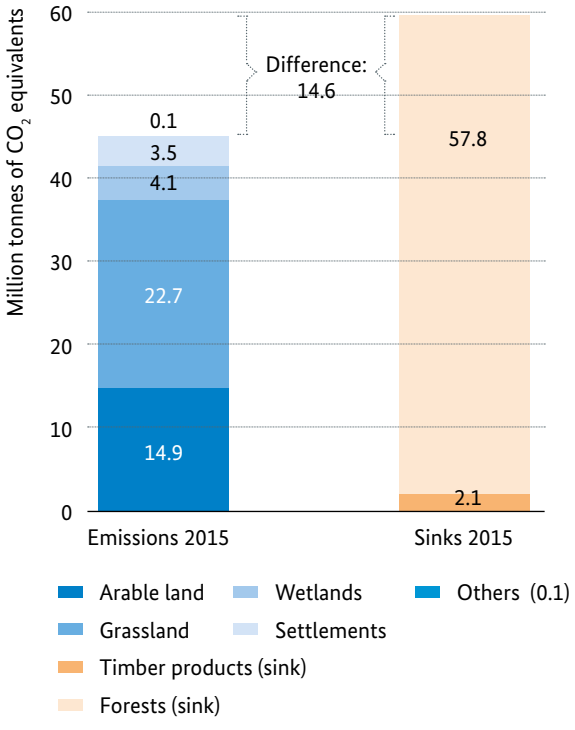
Protecting peatland is an explicit goal of the Federal Government. Although peatland only accounts for six per cent of all agricultural land, it is responsible for roughly 80 per cent of emissions from farmland. As a result, it makes up roughly four per cent of nationwide greenhouse gas emissions. To reduce this relatively high percentage, initiatives are being promoted, including measures to increase the water level in dried peatland.

Figure 38: **Emission developments in LULUCF (incl. sinks)**



Source: UBA (2017a, as of: March 2017)

Figure 39: **Emissions and sinks LULUCF 2015**



Source: UBA (2017a, as of: March 2017)

5. What does climate action mean for the economy and society?

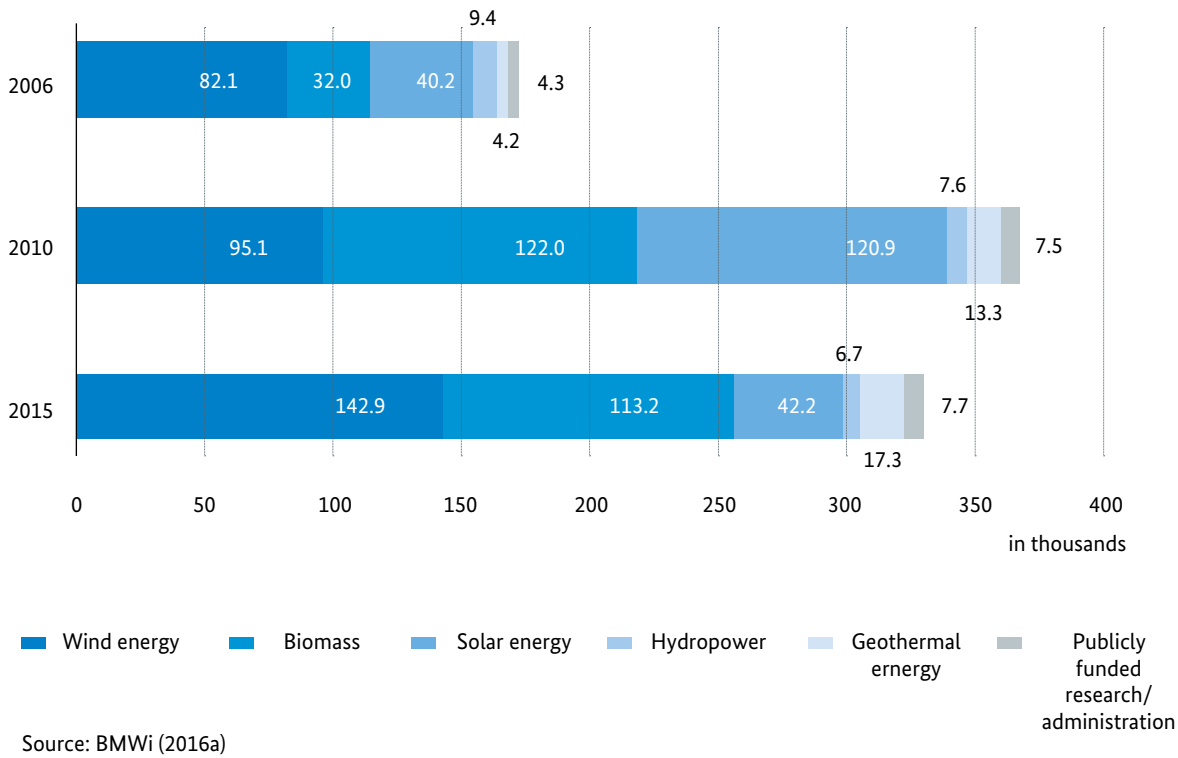
5.1 Jobs

Climate action is more than avoiding greenhouse gas emissions. Expanding renewable energy sources shows that climate action also creates jobs in Germany. There were roughly 330,000 jobs in the renewable energy sector in 2015. This is almost three times as much as in conventional power supply (approximately 117,000, excluding heating supply, coal mining, et cetera). The employment figures in the wind power sector alone exceed this figure at almost 143,000 in 2015. As a result, the renewable energy sector remains an important driver for the German economy, in spite of a slight decrease in recent years (Figure 40).

Implementation of the Federal Government's Climate Action Programme 2020 will create 430,000 additional jobs in the next few years. The economic evaluation shows that the macroeconomic benefit significantly exceeds the costs of the planned climate action measures. Private households in particular could save a total of 26 billion euros in energy costs via the measures in the action programme. These savings can compensate the costs of expanding the electricity grid, which are partially passed on to end consumers.

"Investments in energy efficiency save us money, modernise the country, create jobs and enhance our ability to innovate and compete."
Sigmar Gabriel, Federal Minister of Economic Affairs and Energy

Figure 40: **Development of gross employment due to renewable energy sources in Germany**



Source: BMWi (2016a)

Besides renewable energy sources, efficiency measures also create jobs, especially in the construction trade with energy-efficient new buildings and renovations. Experts expect efficiency measures to create up to 190,000 jobs by 2020.

The number of jobs in climate-friendly energy supply is also increasing globally. In 2015, roughly 8.1 million people were employed in the renewable energy sources sector, approximately five per cent more than in the previous year. Of these, most are in China, where approximately 3.5 million people work in this sector.

The structural change is a challenge for the conventional energy sector. Gradually reducing coal-based electricity generation to achieve climate action targets, could lead to structural upheaval in some regions of Germany. As a result, clear political frameworks and targets are important to ensure an orderly change and offer the affected regions new opportunities. Incorporating all stakeholders involved is also important. That is why a decision was made with the Climate Action Plan 2050 to establish a commission for growth, structural change and regional development. In this way, measures are to be developed by the end of 2018 in coordination with all stakeholders, to combine the economic development, structural change, social acceptability and climate action.

5.2 Investments

New investments in low-carbon technologies strengthen the economy. Investments in climate-friendly solutions like photovoltaics or wind turbines and efficiency measures, for example in the building sector, are key for the implementation of climate policy. Such investments also boost the economy, as most of the value chain is located in Germany, for refurbishment projects in particular. There are many support programmes in related areas, which support sustainable investments. For example, low-interest loans from KfW incentivise investments by commercial companies in improving resource efficiency.

Once again in 2015, investments in energy building refurbishment remained at a high level. Roughly 36.4 billion euros were invested in refurbishing existing residential buildings and a further 16.8 billion euros were invested in refurbishing non-residential buildings. Accordingly, investments in buildings have risen by 700 million euros compared with the previous year. Energy refurbishment of buildings remains one of the most effective ways of increasing energy efficiency.

The costs of renewable energy sources have decreased constantly in recent years. In 2016, more than 12 billion euros were invested in expanding renewable energies. In 2010, this figure was approximately 25 billion euros. Although 2015 was the second-strongest wind expansion year, investments in wind turbines decreased by two billion euros (Figure 41) compared with the previous year. A similar decline in costs was apparent in the development of photovoltaic systems in 2011. At 9.2 billion euros (onshore and offshore), wind power accounted for the highest level of investments in 2016, and now makes up two thirds of all investments in renewable energies in Germany.

Climate-friendly investments are promoted. Support programmes of the Federal Government make investments in climate-friendly projects easier. The KfW programmes for energy building refurbishment and energy-efficient new buildings are now a world-famous success story. The Federal Government is also investing in climate-friendly innovations in research:

- The Integrated Environmental Programme 2030 (IUP) combines environmental and climate action matters with other areas of politics. As in the high-tech strategy (see Section 5.4), the focus will be on an environment- and climate-friendly energy industry, healthy living conditions and sustainable mobility. In addition to this, there is the area of sustainable agriculture and the international dimension. In all areas of action, demonstration projects for new environmentally friendly technologies are a particular focus of support.

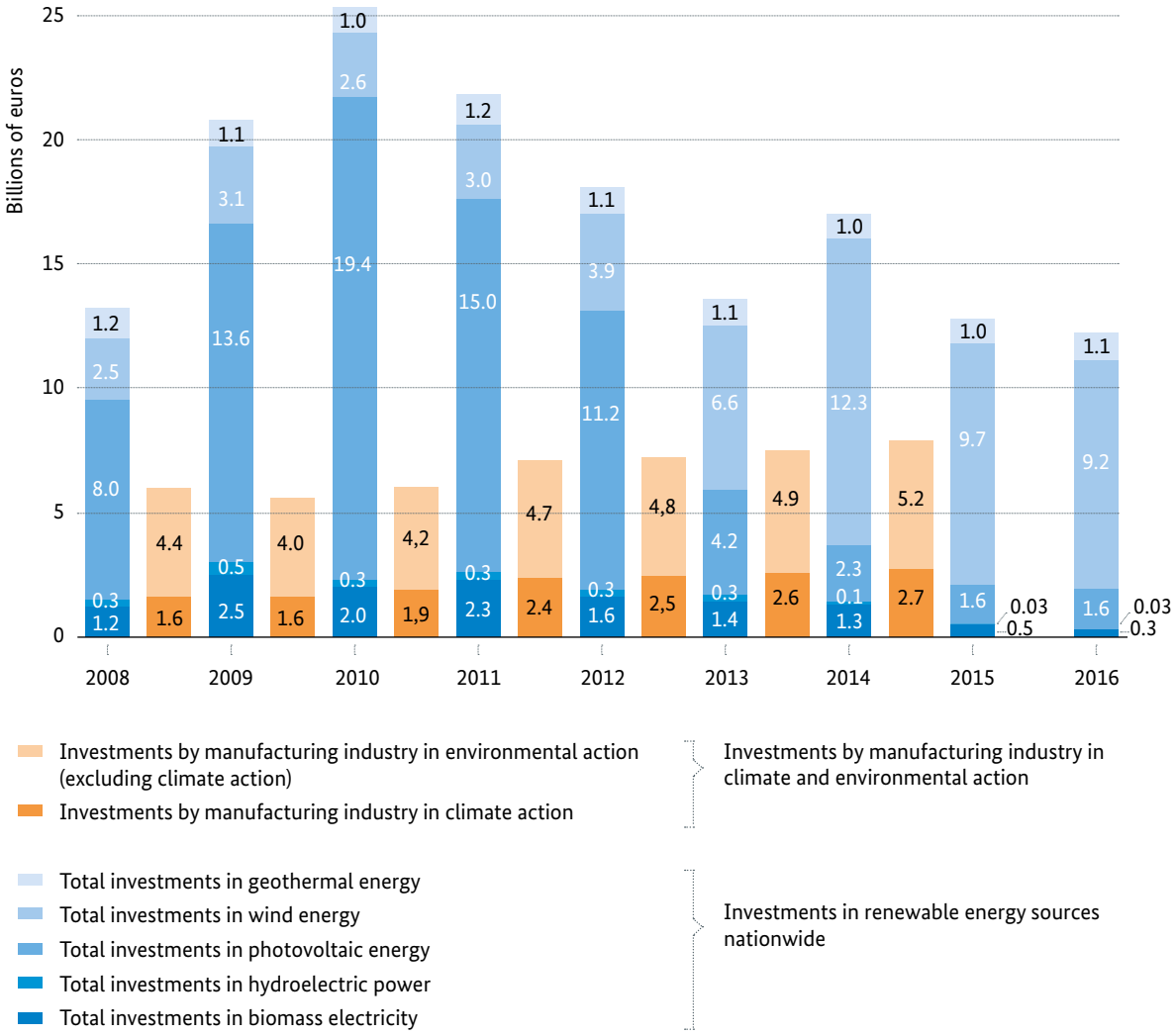
- In the departmental research plan (previously UFO plan), the BMUB defines relevant research questions which the Federal Environment Agency (UBA) finances as tendered research projects.

- The sixth energy research programme of the Federal Government supported research projects with a total of 3.4 billion euros between 2013 and 2016 – 863 million euros in 2015 alone.

- The Federal Government's National Climate Initiative (NKI) has already subsidised more than 10,000 projects in roughly 3,500 municipalities since 2008. In total, NKI has supported over 25,000 projects with more than 750 million euros between 2008 and 2016 in the municipalities, companies and private households target groups. Within the scope of the International Climate Initiative (IKI) more than 500 projects around the world have been funded since 2008 with a volume of around 2.3 billion euros. Since 2017, the European Climate Initiative has also been providing funds for internal European cooperation in climate action.

The Federal Government has created clear political signals for sustainable future planning. The Climate Action Plan 2050 offers a long-term political framework and thus planning certainty for investment decisions. The sector targets of the plan (see also the Spotlight on page 21) outline the climate policy path for the upcoming decades. In this way, companies which base their investment decisions on this and opt for climate-friendly technologies, can avoid costs for subsequent adaptations.

Figure 41: **Selected investments in climate and environmental action**



Sources: BMWi (2016a); AGEE-Stat (2017, as of: February 2017); Federal Statistical Office (2016a)

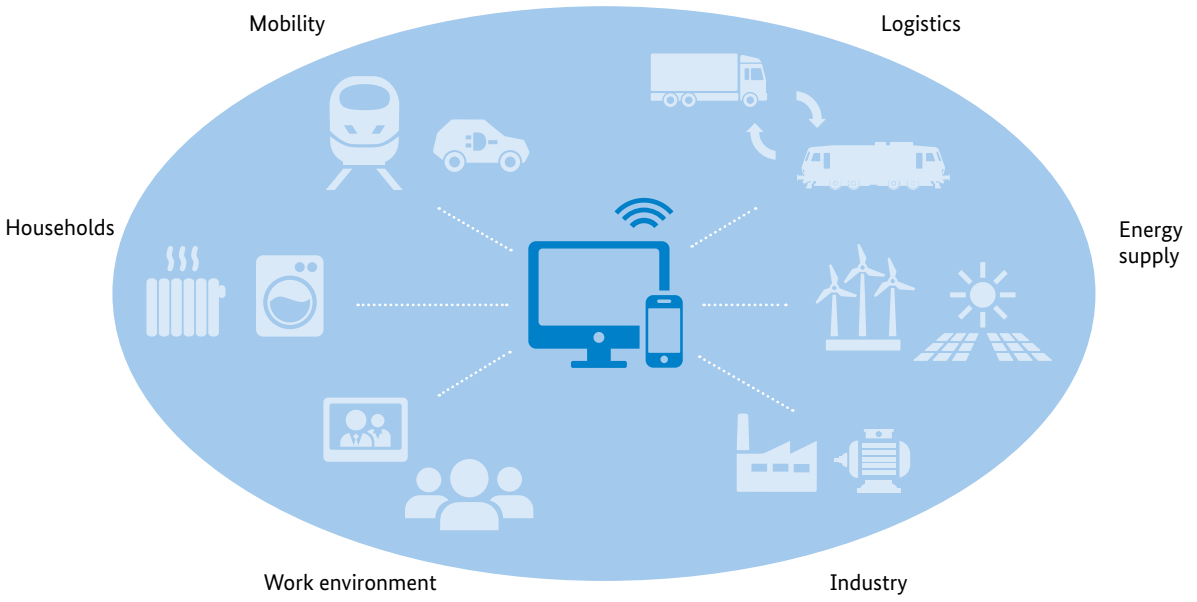
5.3 Innovation

Germany and the EU have proven immense technological innovativeness. Climate action has become an international competition factor and "Greentech made in Germany" is a successful brand. The high investments of the recent years in renewable energies and efficient building services equipment (see Section 5.2) are based on the technical innovations of the recent decades.

Digitisation offers further potential for innovation. The global transition to electronically backed processes triggers changes in all areas and offers opportunities for greater climate action: telephone and video conferences make it easier to work together from different locations; intelligent building services equipment can reduce heat consumption; optimised delivery processes avoid empty runs and reduce fuel consumption in the logistics sector (see schematic diagram in Figure 42). By implementing the "Digital Agenda 2014–2017", the government aims to advance digital change in the renewable energy sector and energy efficiency technologies in particular.

The Federal Government assumes that the market volume of environmental and energy efficiency technologies by 2025 will increase to at least five billion euros. Ambitious climate action targets incentivise companies to position themselves well on the global market for climate action products. While environmental technologies and resource efficiency only accounted for three per cent of added value worldwide in 2013, this figure was already 13 per cent in Germany.

Figure 42: **Efficiency potential through digital networking**



Source: Own diagram

"Digital technologies can [...] increase efficiency, save resources and thus contribute significantly to climate action." Bitkom Digital Association

The law on the digitisation of the energy transition passed in 2016 governs equipping consumers and generators with intelligent measurement systems known as smart meters. By providing precise consumption information and facilitating variable rates, smart meters are intended to help increase energy efficiency. That steers the expansion of intelligent networks and measurement systems, and makes them secure with uniform standards and data privacy stipulations.

Various support schemes promote climate-friendly innovations. For example, the Federal Government's high-tech strategy supports innovations in sustainable management and energy, as well as healthy living and intelligent mobility. To this end, the Federal Government invested 14 billion euros in innovation promotion in 2014 and 2015.

Clean innovations are also supported at a European level. The European framework programme "Horizon 2020", subsidises research projects, that promise "safe, clean and efficient energy" without nuclear power, between 2014 and 2020. It is the largest EU research and innovation programme to date, with an overall volume of almost 80 billion euros. In addition to this, the funding is intended to encourage further private investments, bringing new ideas out of the laboratory into the shops. The programme incorporates a wide range of topics, from agriculture and water management, via telecommunication solutions, right up to humanities aspects related to demographics and behavioural changes.

5.4 Energy security

Climate-friendly electricity generation increases the reliability of supply. Constant availability, affordable prices and a sustainable procurement network are the cornerstones of a reliable energy supply. Renewable energy sources can contribute to increased supply security insofar as they lead to a diversification of the energy mix and use local resources. This is particularly important in Germany, which has hardly any national fossil energy sources. Roughly two thirds of the fossil fuels used (oil, gas and hard coal) in Germany are imported.

Definition: Energy security

The economy and the population depend on a stable energy supply, as everyday workflows would be inconceivable otherwise. Energy security is determined by four factors: first, energy (sources) must be fundamentally present and second, they must be available or usable. Third, the energy must be affordable, and fourth, the form of energy generation must be socially acceptable. The concept of energy security grew in importance during the 1970s oil crisis and has become a key element of national policy since then.

Expanding renewable energy sources reduces energy import costs. When renewable energy sources replace fossil-based power stations, the demand for fossil energy sources falls and so do the import quantities and costs. For example, in 2015 the import costs for fossil energy sources were reduced by almost nine billion euros.

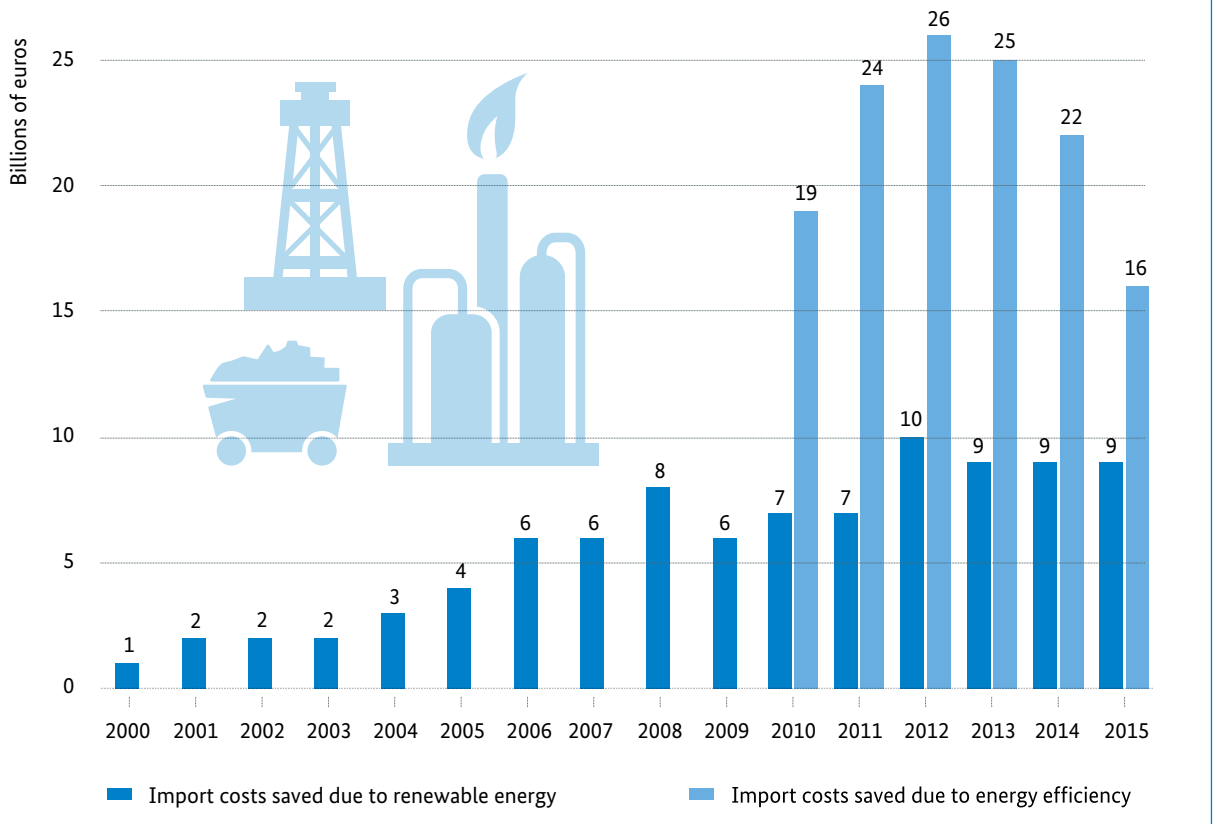
In 2015, fossil fuels with a total value of roughly 57 billion euros were imported, compared with roughly 81 billion euros in the previous year. These savings are also due in part to the low oil price. The average crude

oil price in 2016 was 279.66 euros per tonne, roughly 20 per cent below the average price in 2015.[36]

Energy efficiency contributes to energy security. Efficiency measures reduce the energy demand in general, and thus reduce the dependency on oil and gas. If companies convert to more efficient systems, they not only protect the climate and save energy costs, they also reduce economic uncertainties caused by fluctuating oil and gas prices. Resources can be planned more reliably. Increased energy efficiency also means that the energy demand decreases with constant economic activity at a macroeconomic level, saving import costs. For 2015, the energy costs avoided due to efficiency are estimated at roughly 16 billion euros (Figure 43).

Reduced demand for fossil energy sources reduces geopolitical risks. Germany currently depends on energy imports for approximately 70 per cent of primary energy consumption. One third of the oil and gas resources consumed here and one quarter of the hard coal come from Russia; another part of the oil imports is sourced from the Middle East, and thus from geopolitically unstable regions.

Figure 43: **Reduction in import costs of energy due to renewable energy sources and energy efficiency**



Savings due to energy efficiency before 2010 are not shown because of missing data.
Source: Own diagram based on BMWi (2016a)

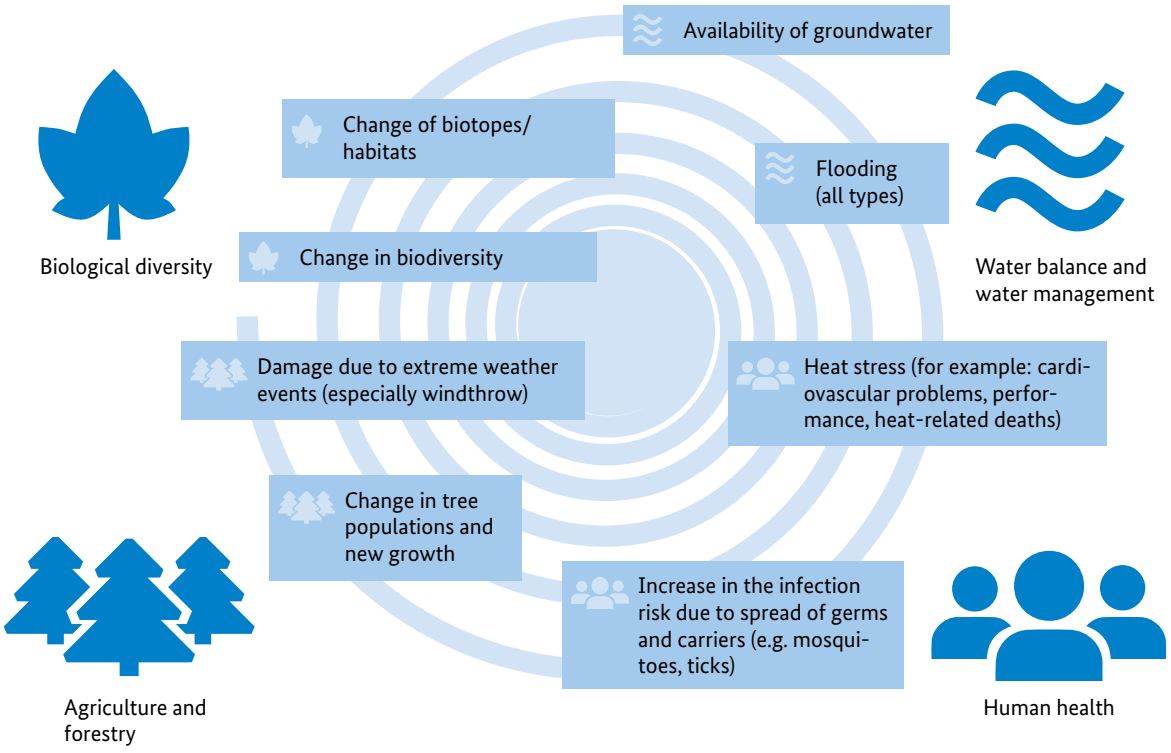
5.5 Environment and health

Climate action is an interdisciplinary task, which benefits human health, nature and biodiversity and the economy equally.

Climate action protects human health. In order to avoid negative effects of climate change like heat stress or changes in the occurrence of allergens like pollen (see Figure 01 and Section 2.1), the increasing rise in temperature must be counteracted. Measures against climate change, such as reducing combustion of fossil fuels, also has positive effects on the air quality. Reducing particulate matter and ozone pollution also helps preserve health.

Climate action preserves biodiversity. Climate action reduces the migration or extinction of animals and plants. In addition, climate action can help combat the causes of extreme weather events like storms and floods, avoiding increasing destruction of habitats (Figure 44). Nature-based adaptation measures, such as urban trees or green façades or roofs boost the quality of life. They cool the air with shading, insulation and evaporation effects, helping preserve urban biodiversity.

Figure 44: **Effects of climate change on the environment and health**



Source: Own diagram based on UBA (2015c)

5.6 Climate action in municipalities

Climate policy combines environmental action with economic development and social participation. With civic projects and dialogue, it supports the transformation to a sustainable society.

Municipalities now play a key role in climate action. This is true especially in the cases of energy supply, municipal buildings, transport and mobility, water, sewage and management of municipal enterprises. By investing in climate-friendly future solutions and supporting political measures in these areas, municipalities can create groundbreaking framework conditions. Municipalities can also influence climate action actively with information, consultation and civic engagement opportunities.

Urban high-density population areas react particularly sensitively to the effects of climate change. Within the framework of the progamme "Measures for adaptation to the effects of climate change", the Federal Environment Ministry promotes projects which respond to the effects of global warming and reduce vulnerabilities locally. Promotion programmes, informational events and competitions enable tailor-made municipal climate action measures. The competition "Climate Active Municipality 2017" organised by the Federal Environment Ministry and the German Institute of Urban Affairs awards prizes for successful projects, for example in building refurbishment or in climate-friendly mobility. The winning projects can inspire other municipalities to take similar measures and facilitate the exchange among themselves.

Education helps protect the climate. With the Federal Government's National Climate Initiative (NKI) (see also Section 5.2), the BMUB has also been initiating and promoting specific climate projects in schools and other educational institutions since 2008. The projects boost awareness of climate action among children, young people and young adults, and promote participation opportunities in climate action. The projects encourage schools to come up with concrete ideas for climate action: in addition to mobile learning services, energy saving measures in school buildings and bicycle-powered cinemas have been implemented.

Information for cities

The Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) provides reliable help with the practical implementation of climate adaptation in cities and regions as well as in the housing industry. A web application presents more than 30 topic-specific short films at klimastadtraum.de (only in German).

The Federal Environment Ministry's Climate Pilot (Klimalotse) introduces municipal representatives to the impacts of climate change and suggests ways municipalities can adapt. In five modules, important measures are explained step by step:

- Module 1 "Understanding and describing climate change" shows foreseeable effects of climate change
- Module 2 explains how cities can identify and assess their individual vulnerability
- Module 3 looks at possible protective measures
- Module 4 explains the legal framework conditions for specific steps
- Module 5 presents options for tracking and evaluation

The European Environment Agency (EEA) also offers a comprehensive guide for cities on the Climate-ADAPT website.

The online portal Klimaschutzschulenatlas.de (only in German) now shows over 3,550 schools which are committed to climate action.

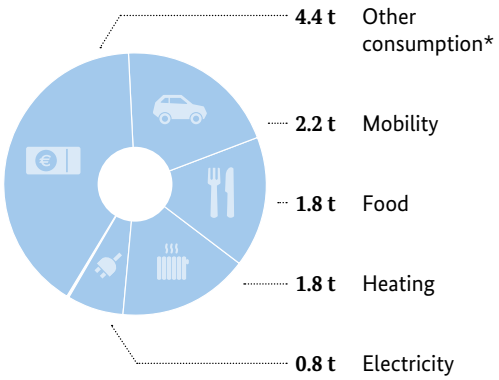
5.7 Sustainable consumption

With their purchase decisions, consumers can contribute to climate action. The environmental and health consciousness of German consumers has greatly boosted the production and sales of green products in recent years. Buying organic and regional products can help shorten transport distances, reduce refrigeration times and save emissions. Heating and electricity consumption make up the lion's share of the average German citizen's CO_2 footprint, followed by transport and food. Figure 45 shows further details.

The EU ecodesign and energy consumption labelling guidelines promote sustainable consumption. Energy consumption of products is rendered visible for users. Criteria for environmental compatibility and service life were taken into account in the evaluation. Labels in accordance with the EU directive immediately show minimum standards that help users make purchase decisions. Together with the voluntary environmental label, these instruments promote market penetration of the most environmentally friendly and most resource- and/or energy-efficient technology in a certain product group (top runner approach). The Federal Government also supports climate-friendly consumption with a range of initiatives. The "National Programme for Sustainable Consumption" is intended to encourage consumers to increasingly choose environmentally friendly products and services and thus to spread sustainable consumption.

Various labels support sustainable consumer behaviour, by identifying environmentally friendly products. One of the best-known labels in Germany is the "Blauer Engel" (Blue Angel), the Federal Government's environmental label to protect people and the environment that recognises over 12,000 environment- and climate-friendly products and services in areas like households, offices and gardens.

Figure 45: **Greenhouse gas emissions of a German average citizen (in CO_2 equivalents)**



*This includes, among other things, clothing, shoes, furniture, household appliances as well as leisure and recreation services and holiday activities.

Source: UBA (2016b)

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Environmental costs

Prices and costs influence our consumer behaviour: In recent decades, flying has become much cheaper. That is why there are more than twice as many airline passengers in Germany than in 2000.[37] Airline tickets do not include the environmental costs. However, airline passengers can pay voluntary compensation to offset their emissions. This concept is based on emissions trading.

Road traffic also has high environmental costs. According to a study by the Federal Environment Agency (UBA),[38] road traffic cost the environment over 52 billion euros in 2014. The loss of biodiversity due to the use of pesticides in agriculture is also a form of costs which are not reflected in the price of foods.

6. Glossary

Biofuels
Liquid or gaseous fuels produced from biomass. Examples include biodiesel, bioethanol and biogas.

Carbon dioxide (CO_2)
Colourless and odourless gas that is a natural part of the atmosphere. As a by-product of energy generation, carbon dioxide occurs primarily when burning fuels containing carbon. Carbon dioxide is the most important of the climate-relevant atmospheric trace gases.

Carbon leakage
Due to additional costs from emissions trading, industrial production is outsourced to countries where no climate action requirements or low requirements apply. This also outsources the associated (climate gas) emissions.

CO_2 equivalents
Unit for the greenhouse warming potential of a gas. CO_2 equivalents show the quantity of a gas that would have the same effect as CO_2 over a 100-year period.

Cogeneration (CHP, combined heat and power generation)
Simultaneous generation of electricity and heat in one power generation plant.

Decarbonisation
Increasing use of low-carbon sources of energy for economic action.

Direct marketing
Sale of electricity from renewable energy sources to wholesale buyers or on the electricity exchange (for example on the electricity exchange in Leipzig). With subsidised direct marketing, plant operators also receive a market bonus in addition to the sales revenue.

Effort sharing
Binding emission targets in the individual Member States for sectors which are not covered under EU emissions trading, in particular transport, households, commerce/trade/services and agriculture.

Electricity Market White Paper / Electricity Market 2.0
Publication by the Federal Ministry for Economic Affairs and Energy (BMWi) on changes in the electricity market design.

Emission certificate
Certified right to emit a certain quantity of a pollutant in a specific period. The Kyoto Protocol defines emission certificate trading as a tool to restrict the output of greenhouse gases. The EU emissions trading system implements emission certificate trading.

Energy efficiency
Ratio of benefit to the energy required.

Energy productivity
Ratio of the overall macroeconomic performance to the energy used (inverse of energy intensity).

European emissions trading system (EU-ETS)
Since 2005, emissions trading has been the central EU-wide instrument for reducing CO_2 emissions, making it the main instrument for implementing the EU's climate goals. It incorporates emitters in the energy and industry sectors, which can trade emission allowances among one another.

External environmental costs
Costs (in particular from environmental damage), which are incurred when producing economic assets, but are not borne by the producer.

F gases
Fluorinated greenhouse gases used as refrigerants in cooling and air conditioning systems, as propellants in sprays, as propellants in foams and insulation and as a fire extinguishing agent.

Feed-in tariff
Remuneration for electricity from renewable energy sources defined by the government and embedded in the Renewable Energy Sources Act (EEG).

Final energy
Part of primary energy that reaches the consumer after deduction of transfer and conversion losses, for example district heating, electricity, petrol, heating oil, natural gas, biogas and hydrogen.

Fossil fuels
Energy fuels that have been produced over millions of years from biomass and consist of different carbon compounds: oils, coals, gases.

Green technologies (GreenTech)
Environmentally friendly, sustainable, resource- and energy-saving technologies.

Greenhouse gases
Atmospheric trace gases that contribute to the greenhouse effect and can be both natural and anthropogenic, for example carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorinated hydrocarbons (PFCs).

Greenhouse gas neutrality
Total anthropogenic greenhouse gas emission (for example by burning fuels) and absorption (for example by natural sinks, future technologies) of human-made greenhouse gas emissions is zero.

Gross electricity consumption
Total of domestic electricity generation and flows of electricity from overseas, less flows of electricity to other countries.

Intergovernmental Panel on Climate Change (IPCC)
An intergovernmental committee of experts on climate matters, that has been operating under the patronage of the United Nations since 1988.

Market Stability Reserve (MSR)
An instrument designed by the EU Commission to reform the EU-ETS. The stability reserve is intended to counteract the continuing price drops in emission certificates, by reducing the number of certificates traded on the market.

Methane (CH_4)
Non-toxic, colourless and odourless gas. After carbon dioxide (CO_2), it is the second- most significant greenhouse gas emitted by humans.

National Climate Initiative (NKI)
Support programme of the Federal Environment Ministry for climate action.

Plug-in hybrid
All vehicles that use two different drives (generally combustion and electric motors) and can be charged by plugging them in.

Primary energy
Mathematically useful energy content of a naturally occurring energy source, before it is converted into another form of energy.

Primary energy consumption
Total of energy sources used, including changes in stock and the balance of purchases and deliveries.

Renewable energies
Energy sources that, according to human measures of time, are available for ever. The three original sources are: solar radiation, geothermal energy and tidal energy. They can be used either directly or indirectly in the form of biomass, wind, hydropower, ambient heat and wave energy.

Renewable Energies Heat Act (Erneuerbare-Energien- Wärmegesetz, EEWärmeG)
The "Act on the Promotion of Renewable Energies in the Heat Sector" (short version: Renewable Energies Heat Act, EEWärmeG) dates back to 2009. It obliges the owners of new buildings to meet part of their heating and cooling needs from renewable energy sources. The first amendment of the act entered into force in 2011.

Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG)
The 2000 Act Prioritising Renewable Energy Sources contains the priority purchase obligation of renewable energy sources by grid operators. It also governs the (decreasing) remuneration rates for individual generation types and the process of allocating the resulting additional costs to all electricity buyers. Amendments to the Act entered into force in 2004, 2009, 2012 and 2017. Since 2017, the remuneration amounts for electricity under the EEG are no longer defined by the government, they are determined by tenders on the market.

Sink
Reduction of emissions by absorbing and storing CO_2 in plants and soil.

Source principle
Allocation of emissions to the point of origin.

United Nations Framework Convention on Climate Change (UNFCCC)
First international agreement that refers to climate change as a serious problem and obliges the community of states to take action. The Climate Framework Convention was adopted at the 1992 United Nations Conference on Environment and Development, and has been ratified by 194 states since then. It entered into force in 1994.

7. List of abbreviations

AGEB	Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)
AGEE	Working Group on Renewable Energy (Arbeitsgruppe Erneuerbare Energien)
APA	Adaptation Action Plan (Aktionsplan Anpassung)
BBSR	Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung)
BMEL	Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft)
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit)
BMWi	Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
CAP	EU Common Agricultural Policy
CAT	Climate Action Tracker
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CTS	Commerce, Trade and Services sector (Gewerbe / Handel / Dienstleistungs- Sektor)
DAS	German Adaptation Strategy (Deutsche Anpassungsstrategie)
DEG	German Investment and Development Society (Deutschen Investitions- und Entwicklungsgesellschaft)
DEHSt	German Emissions Trading Authority (Deutsche Emissionshandelsstelle)
DüV	Fertiliser Ordinance (Düngeverordnung)
EDGAR	Emission Database for Global Atmospheric Research
EEA	European Environment Agency
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EEWärmeG	Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz)
ELER	European Agricultural Fund for Rural Development (Europäischer Landwirtschaftsfonds für die Entwicklung des ländlichen Raums)
EnEG	Energy Savings Act (Energieeinsparungsgesetz)
EnEV	Energy Savings Ordinance (Energieeinsparverordnung)
ESG	Building Energy Efficiency Strategy (Energieeffizienzstrategie Gebäude)
EU28	28 Member States of the European Union
EU-ETS	EU Emission Trading System
F-gas	Fluorinated greenhouse gas
g	Gram(s)
GAK	Joint Task for the “Improvement of Agricultural Structures and Coastal Protection” (Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz)
GDP	Gross Domestic Product
GDV	German Insurance Association (Gesamtverband der Deutschen Versicherungswirtschaft)
GHG	Greenhouse gas
GJ	Gigajoule
Gt	Gigatonne
HFC	Fluorinated hydrocarbon
HGV	Heavy Goods Vehicle
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change

KfW	German National Development Bank (Kreditanstalt für Wiederaufbau)
kWh	Kilowatt hour
LEEN	Learning energy efficiency networks (Lernende Energieeffizienz-Netzwerke)
LULUCF	Land use, land use change and forestry
Mill.	Million
MJ	Megajoule
N_2O	Nitrous oxide
NAPE	National Action Plan on Energy Efficiency (Nationaler Aktionsplan Energieeffizienz)
NDC	Nationally Determined Contribution
NKI	National Climate Initiative (Nationale Klimaschutzinitiative)
OECD	Organisation for Economic Cooperation and Development
PFC	Perfluorinated hydrocarbon
PJ	Petajoule
Pkm	Passenger kilometre
ppm	Parts per million
SF_6	Sulphur hexafluoride
SME	Small and Medium-sized Enterprise
t	Tonne
TWh	Terawatt hour
UBA	Federal Environment Agency (Umweltbundesamt)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

8. Endnotes

1. Fischer, E.M., Knutti, R. (2015); WMO (2017); IPCC (2013)
2. UNEP, GRID Europe (2004); UBA (2014); GDV (2016); BBK (2013)
3. UBA (2015a), WARNSIGNAL KLIMA (CLIMATE WARNING SIGNAL) (2014); UBA (2015b)
4. UNEP, GRID Europe (2004)
5. GDV (2012)
6. For further information: Bundesregierung (2015)
7. Matthews, D. et al. (2014)
8. OECD (2015)
9. UBA (2017c)
10. AGEE-Stat (2017)
11. Statistisches Bundesamt (2016b); BMWi (2017a)
12. AGEB (2016)
13. A very small percentage is caused by the combustion facilities for gas transport
14. Fraunhofer ISE (2015)
15. BMWi (2015a)
16. UBA (2016c)
17. DEHSt (2016)
18. Bundesregierung (2016)
19. Bundesrat (2016)
20. AGEB (2016)
21. Kraftfahrtbundesamt (2017)
22. BMUB (2015)

23. Bundesregierung (2016)
24. ZIV (2016)
25. Bundesregierung (2016)
26. AGEB (2016)
27. Fraunhofer ISI (2015)
28. BMUB (2014)
29. AGEB (2016)
30. BMWi (2015b)
31. BMWi (2016c)
32. BMUB (2012)
33. BMEL (2016)
34. UBA (2016d)
35. BFN (2015)
36. BMWi (2017a)
37. Statistisches Bundesamt (2017)
38. UBA (2016e)

9. Bibliography

AGEB (2016): Evaluation Tables of the Energy Balance for Germany 1990 to 2015. www.ag-energiebilanzen.de
AGEB (2017): Bruttostromerzeugung in Deutschland ab 1990 nach Energieträgern. Berlin.
AGEE-Stat (2017): Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland. www.erneuerbare-energien.de
BBK (Federal Office of Civil Protection and Disaster Assistance) (2013): Press Release from the Bundesamt für Bevölkerungsschutz und Katastrophenhilfe dated 12/08/2013. www.bbk.bund.de
BFN (Federal Agency for Nature Conservation) (2015): Artenschutz-Report 2015. Bonn.
BMEL (2016): EU agricultural policy. www.bmel.de
BMUB (2012): Waste policy. www.bmub.bund.de
BMUB (2014): Industrie & Gewerbe / Handel / Dienstleistungen. www.klimaschutzplan2050.de
BMUB (2015): Klimabilanz Elektromobilität. www.bmub.bund.de
BMUB (2016): Climate Action Plan 2050: Cabinet adopts guide to climate neutral Germany. Press release no. 280/16.
BMWi (2015a): 3. Nationaler Aktionsplan Energieeffizienz. www.bmwi.de
BMWi (2015b): Energy Efficiency Strategy for Buildings. Berlin.
BMWi (2016a): Fifth “Energy Transition” Monitoring Report. Berlin.
BMWi (2016b): Zahlen und Fakten Energiedaten: Gesamtausgabe. Berlin.
BMWi (2016c): Advice and funding. www.bmwi.de
BMWi (2017a): Zahlen und Fakten Energiedaten. Nationale und Internationale Entwicklung. Berlin.
Bundesrat (2016): Entwurf eines Gesetzes zur Änderung der Bestimmungen zur Stromerzeugung aus Kraft-Wärme-Kopplung und zur Eigenversorgung. www.bundesrat.de
Bundesregierung (Federal Government) (2015): Fortschrittsbericht zur Klimaanpassung. Deutsche Anpassungsstrategie an den Klimawandel (DAS). www.bmub.bund.de
Bundesregierung (Federal Government) (2016): Klimaschutzplan 2050. www.bmub.bund.de
CAT (2015): Global Emissions Pathways. www.climateactiontracker.org
DEHSt (2016): Treibhausgasemissionen 2015. Emissionshandelspflichtige stationäre Anlagen und Luftverkehr in Deutschland (VET-Bericht 2015). Berlin.
DEHSt (2017): Emissions trading: Emissions reductions in Germany only minimal. Press release no.13/2017 dated 11/04/2017. www.dehst.de
Edenhofer, O. et al. (2014): Technical Summary. In: Climate Change 2014: Mitigation of Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

EDGAR (2014): GHG (CO2, CH4, N2O, F-gases) emission time series 1990-2012 per region/country. www.edgar.jrc.ec.europa.eu
EDGAR (2016): CO2 time series 1990-2015 per capita for world countries. www.edgar.jrc.ec.europa.eu
EEA (2016a): Greenhouse gas data viewer. www.eea.europa.eu
EEA (2016b): EU Emissions Trading System (ETS) data viewer. www.eea.europa.eu
EEA (2017): Climate Change, impacts and vulnerability in Europe 2016. An indicator-based report. No. 1/2017. www.eea.europa.eu
Fischer, E. M., Knutti, R. (2015): Anthropogenic contribution to global occurrence of heavy-precipitation and high-temperature extremes. In: Nature Climate Change. Vol.5, Pp.560-564.
Fraunhofer ISE (2015): Recent facts about photovoltaics in Germany. www.ise.fraunhofer.de
Fraunhofer ISI (2015): Energieverbrauch des Sektors Gewerbe, Handel, Dienstleistungen (GHD). www.isi.fraunhofer.de
GDV (2012): Auswirkungen des Klimawandels auf die Schadensituation in der deutschen Versicherungswirtschaft. Kurzfassung Hochwasser. www.gdv.de
GDV (2016): "Elvira", "Friederike" & Co. verursachen Schäden von 1,2 Milliarden Euro. www.gdv.de
IPCC (2013): Climate Change 2013. The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers. www.ipcc.ch
Kraftfahrtbundesamt (Federal Motor Transport Authority) (2017): Personenkraftwagen am 1. Januar 2017 www.kba.de
Matthews, D. et al. (2014): National contributions to observed global warming. In: Environmental Research Letters. Vol. 9. www.iopscience.iop.org
OECD (2015): Carbon Dioxide Emissions Embodied in International Trade. www.oecd.org
Statistische Ämter der Länder (Statistical Offices of Federal States) (2016): Umweltökonomische Gesamtrechnungen der Länder. www.ugrdl.de
Statistisches Bundesamt (Federal Statistical Office) (2016a): Investitionen für den Umweltschutz im produzierenden Gewerbe. Fachserie 19 Reihe 3.1. Wiesbaden.
Statistisches Bundesamt (2016b): Population. www.destatis.de
Statistisches Bundesamt (2017): Air passengers embarking in Germany, by continent of destination. www.destatis.de
UBA (2014): Fit für den Klimawandel. www.umweltbundesamt.de
UBA (2015a): Monitoringbericht 2015: Klimaentwicklung in Deutschland. www.umweltbundesamt.de
UBA (2015b): Einfluss des Klimawandels auf die Biotropie des Wetters und die Gesundheit bzw. die Leistungsfähigkeit der Bevölkerung in Deutschland. Dessau-Roßlau.
UBA (2015c): Vulnerabilität Deutschlands gegenüber dem Klimawandel. Dessau-Roßlau.
UBA (2016a): Emissionen im Personenverkehr. www.umweltbundesamt.de
UBA (2016b): CO2-Rechner. www.uba.co2-rechner.de
UBA (2016c): Emissionsquellen. www.umweltbundesamt.de
UBA (2016d): Ökologischer Landbau. www.umweltbundesamt.de
UBA (2016e): What matters 2016. www.umweltbundesamt.de
UBA (2017a): Nationale Trendtabellen für die deutsche Berichterstattung atmosphärischer Emissionen. Dessau.
UBA (2017b): Energieproduktivität. www.umweltbundesamt.de
UBA (2017c): Climate footprint 2016: Transport sector and cool weather cause spike in emissions. Press release no. 09/2017
UNEP (2015): The Emissions Gap Report 2015. United Nations Environment Programme (UNEP). Nairobi.
UNEP, GRID Europe (2004): Impacts of Summer 2003 Heat Wave in Europe. In: Environment Alert Bulletin.
UNFCCC (2015): National greenhouse gas inventory data for the period 1990-2013. www.unfccc.int
WARNSIGNAL KLIMA (WARNING SIGNAL: CLIMATE) (2014): Die Auswirkungen von thermischen Belastungen auf die Mortalität. www.klima-warnsignale.uni-hamburg.de
World Bank (2016): Population, total. www.data.worldbank.org
WMO (2017): WMO confirms 2016 as hottest year on record, about 1.1 °C above pre-industrial era. www.public.wmo.int
WRI (2015): CAIT Climate Data Explorer. Washington, DC: World Resources Institute. www.cait.wri.org
ZIV (Bicycle Industry Association) (2016): Gemeinsame Presseinformation: Europäische Norm macht Pedelec- und E-Bike-Batterien sicherer. Press release of the Bicycle Industry Association dated 09/11/2016. www.ziv-zweirad.de

www.bmub.bund.de/english