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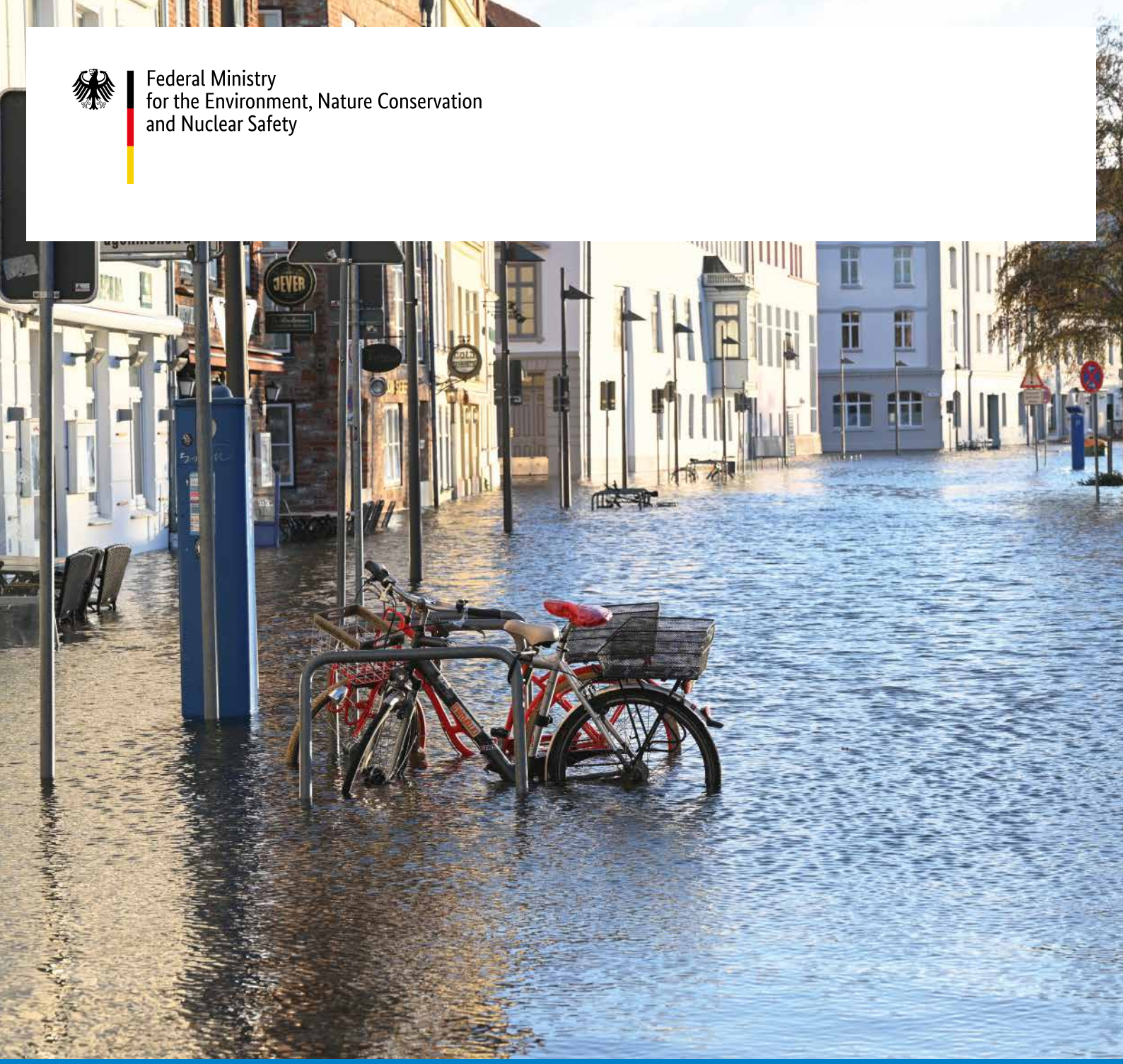

Climate Action in Figures

Facts, Trends and Incentives for German Climate Policy
2020 edition

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Foreword

We are in the midst of the coronavirus pandemic. We cannot yet fully grasp the impacts of the worldwide crisis. Nonetheless, we must not lose sight of other global crises like climate change, which are still with us and progressing, irrespective of the virus. Scientists are still searching for a remedy for COVID-19. However, thanks to decades of research, we already know the diagnosis and therapy when it comes to climate change.

The dramatic impacts climate change can have if we do not resolutely reduce emissions have been shown in the two latest special reports of the Intergovernmental Panel on Climate Change (IPCC). In Germany too, we are already feeling the impacts of climate change. The parties to the Paris Agreement are called on to improve their Nationally Determined Contributions (NDCs). We must take stock and come to a common agreement on intensifying climate action, at the latest by the next UN Climate Change Conference in Glasgow, which will now take place in 2021. In spite of the coronavirus pandemic, we must continue the fight for more climate action, shoulder to shoulder with our international partners. To this end, we held the 11th Petersberg Climate Dialogue as a video conference at the end of April 2020.

With the European Green Deal, the new European Commission has also deemed climate action a focus of the coming years and proposed numerous measures intended to achieve the goal of greenhouse gas neutrality in the European Union (EU) by 2050. Plans to finance a just structural transition and a proposal for an EU Climate Law have already been put forward.

In Germany, intensive work on the part of the Climate Cabinet has borne fruit. The adoption of the Climate Action Programme 2030 and the Bundestag's passage of the Climate Change Act are important steps forward. In this legislation, we established binding annual greenhouse gas emission budgets for all sectors until 2030 and agreed on a mechanism for correction. Now all of the German ministries are climate action ministries. In the next four years we will also have to make pandemic recovery money available for climate action, in addition to the 54 billion euros in investments the Federal Government is making. The overall projection on the Climate Package, published in spring 2020, shows that we are generally on the right path in the energy, industry and waste sectors. Although I am pleased about the Climate Package, I also know that we still have a long way to go before we reach our goal of a greenhouse gas-neutral society and economy. Nonetheless, I applaud the reduction of greenhouse gas emissions in 2019. We have drawn closer to the target path with reductions of 35.7 per cent compared to 1990.

We base our climate policy on facts. Since climate action is a task for the whole of society, we are making these facts transparent and available to all. This latest edition of Climate Action in Figures continues to provide this transparency.

I hope you find Climate Action in Figures both enjoyable and informative.

Svenja Schulze

Federal Minister for the Environment, Nature Conservation and Nuclear Safety

1. Why is Germany committed to an active climate policy?

Summary

As a result of human activities that cause greenhouse gas emissions, the global average temperature has risen by roughly 1°C since the start of industrialisation.

The consequences of global warming are already evident today. Scientists have found indications that the West Antarctic Ice Sheet has already started to flow out into the sea. In consequence, the sea level around the world could rise by more than three metres. The permanent impact of climate change on the oceans and high mountain regions is increasing drastically. Furthermore, global warming is threatening human livelihoods with climate changes in rural areas. Germany too is increasingly affected by climate change. Compared with pre-industrial levels, the average annual temperature has already risen by 1.5°C, which is significantly above the global temperature increase. The associated consequences have left their mark in recent years.

Historically, Germany accounted for 4.6 per cent of greenhouse gas emissions since 1850. The annual per capita CO_2 emissions are now roughly twice the global average, at 9.2 tonnes. As an industrial nation, Germany has a particular responsibility to combat climate change. Germany therefore strives to be a role model in climate action and supports other countries through international climate funding schemes.

1.1 Climate change – causes and consequences

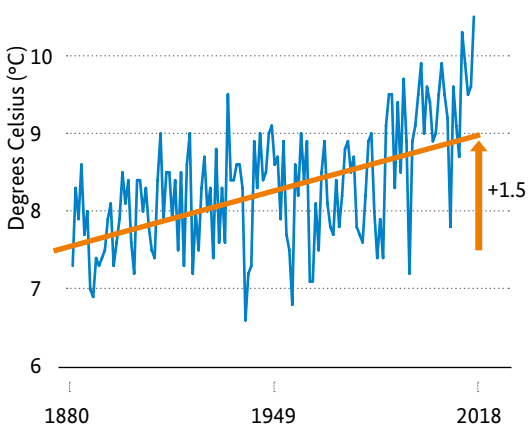
The global average temperature has risen by roughly 1°C since the start of industrialisation. This increase was brought about by human activities that cause greenhouse gas emissions. The proliferation of greenhouse gases in the atmosphere heats the lower strata of air, exacerbating anthropogenic, or human-induced, climate change. In terms of volume, carbon dioxide (CO_2) is the most common greenhouse gas. It is released in particular when fossil fuels are burned and large-scale deforestation takes place. Since the start of industrialisation, the absolute CO_2 concentration has risen roughly 44 per cent overall, compared with the preceding 10,000 years.[1] The average annual rates of increase in CO_2 concentration have almost quadrupled since the 1950s. Besides CO_2, the concentration of other climate-relevant greenhouse gases has also increased significantly. Examples include methane (CH_4) and nitrous oxide (N_2O), which arise primarily in agriculture.

The consequences of global warming are already evident today. A global warming of roughly 1.5°C significantly exacerbates the impact of climate change. With the currently implemented climate change mitigation measures, temperatures would rise by that amount between 2030 and 2052. The Special Report on the Consequences of Global Warming by the Intergovernmental Panel on Climate Change (IPPC), published in October 2018, revealed that the risks to humans and nature are even greater than previously assumed.[2] Even if global warming is limited to 1.5°C, extreme weather events like heat waves, torrential rain, flooding and droughts will occur ever more frequently in several regions of the world. There may be extensive losses of flora and fauna habitats.

Climate change is already having a dramatic impact on high mountain and polar regions, oceans and rising sea levels today, as revealed by the IPCC Special Report on the Ocean and the Cryosphere of September 2019.[3] It points to the danger of landslides, avalanches and floods, potentially affecting up to 670 million people in high mountain regions if glaciers and permafrost continue to thaw. The melting ice caps in Greenland are causing the sea level to rise further. Scientists believe that it might rise by 1.1 metres by 2100. Extreme water levels and more frequent tropical hurricanes would particularly affect the over 700 million people who live near low coasts and in small island nations. Continued warming of the oceans reduces mixing of water strata. As a result, marine creatures do not receive enough oxygen and nutrients. Accordingly, climate change is reducing potential fishing catches worldwide and changing the regional distribution of fishing resources. Especially for communities dependent on fishery, this increases the risks for a secure food supply and health. Marine heat waves are occurring more frequently and are increasing in intensity. This is a threat to sensitive ecosystems like coral reefs in particular. Global warming is changing the climate and threatening human livelihoods in rural areas too, as reported in the August 2019 IPCC Special Report on Climate Change and Land.[4] In many regions, the air temperature above the land surface has risen almost twice as much as the global average temperature since the pre-industrial period, leading to this threat. Warming is causing vegetation losses and extinction, more and more forest fires, desertification and land degradation. Ultimately, that endangers food security in the regions in question.

From a global warming of 1.5°C, the climate system could cross certain tipping points. While a gradual warming of the climate is often discussed, the climate might also undergo sudden and particularly marked changes. Such processes occur when the climate passes

Figure 01: **Increase in the annual average temperature in Germany since weather records began**



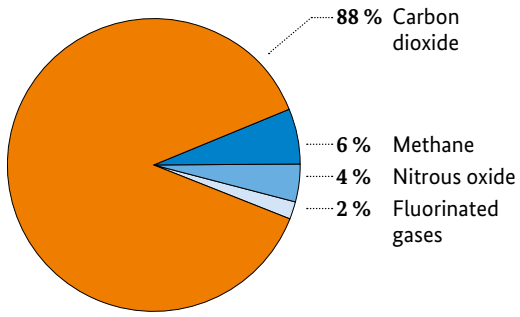
Source: DWD (2020)

i

Greenhouse gases and their origins

The Kyoto Protocol defines carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated greenhouse gases (F-gases) as greenhouse gases. They each account for varying shares of Germany's greenhouse gas emissions (Figure 02). While CO_2 is primarily released when fossil fuels are burned, methane and nitrous oxide are largely produced in agriculture and forestry, particularly in livestock farming. Unlike the other greenhouse gases, fluorinated gases do not occur in nature. The impacts of methane, nitrous oxide and F-gases on the climate are stated in CO_2 equivalents. This unit indicates the extent to which a gas contributes to global warming, relative to the same quantity of CO_2.

Figure 02: **Shares of greenhouse gases in Germany in CO_2 equivalents (2018)**



Source: UBA (2020a)

Carbon dioxide (CO_2) is an odourless and colourless gas that remains in the atmosphere for an average of 120 years. Carbon dioxide accounts for the majority of the greenhouse gas caused by humans. It is primarily released when coal, crude oil and gas are burned to generate electricity and heat. But CO_2 also occurs in households, transport and industrial production.

Methane (CH_4) is an odourless and colourless, highly flammable gas produced when organic material decomposes in an anaerobic environment, for example in animal stomachs, sewage treatment plants and landfills. While methane's atmospheric residence time of roughly 12 years is significantly lower compared to CO_2, its impact on the climate is roughly 25 times higher.

Nitrous oxide (N_2O) is a colourless gas with a sweet odour. While it is only a trace gas in the atmosphere, its impact on the climate is 298 times greater in contrast with CO_2. It is emitted into the atmosphere by nitrogenous fertiliser and livestock farming as well as through industrial chemical processes.

F-gases (HCFC, CFC, SF_6 and NF_3) are primarily produced as propellants, coolants or extinguishing agents, or used in sound insulation panels. Due to their extreme persistence in the atmosphere, their impact on the climate is 100 to 24,000 times higher than CO_2.

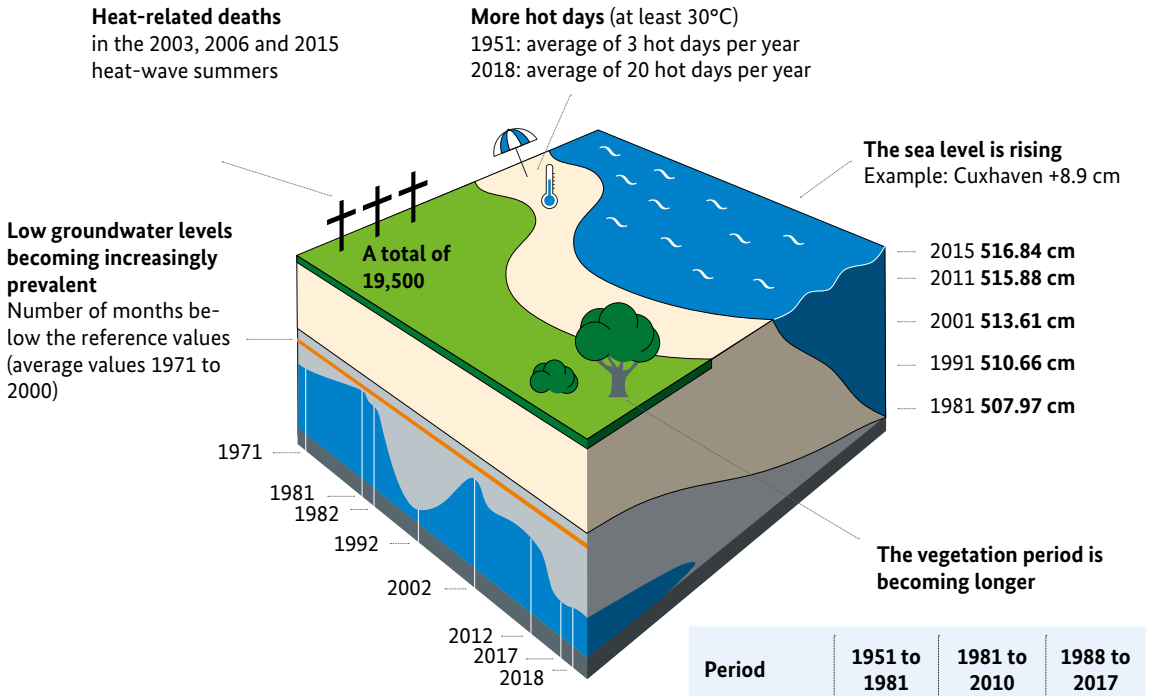
specific critical thresholds, or tipping points, thus intensifying climate change. Starting from a given temperature rise, the climate system reacts with irreversible changes. For example, if the Arctic sea-ice were to melt, the temperature in the Arctic would rise at roughly double the global average rate.[5] This ice-albedo feedback loop occurs because the land mass or sea uncovered by the receding ice can absorb more solar heat, speeding up the melting of the remaining ice. Should the Arctic permafrost in Siberia and North America melt, significant quantities of CO_2 and methane that have been stored there since the last ice age would be released. The associated emission potential is immense, as the carbon trapped in permafrost accounts for roughly 25 per cent of the global soil carbon.[6] If these greenhouse gases were emitted, anthropogenic global warming would increase significantly.

Germany is increasingly affected by climate change too (Figure 03). Compared with pre-industrial levels, the average annual temperature in Germany has already risen by 1.5°C. This value is above the global

temperature increase of 1°C (Figure 01). With an average temperature of 10.5°C, 2018 was the hottest year in Germany since the start of regular weather records in 1881.[7] With an average temperature of 10.2°C, 2019 was also one of the hottest years since records began. The cluster of particularly hot years is a clear sign of global warming, which increases the risks of extreme heat and droughts as well as torrential rain and the associated flooding. For the first time in 2018, Germany was one of the three countries most affected by extreme weather conditions worldwide.[8]

Further risks relate to drinking water supply, the health system and food security as a consequence of crop failures. German forests are also exposed to the effects of climate change (see Section 3.8).

Figure 03: **Selected consequences of climate change in Germany**



Period	1951 to 1981	1981 to 2010	1988 to 2017
Duration of the vegetation period in days	222	230	232

Source: UBA (2019a)

1.2 Climate preparedness – adaptation to climate change

Climate change calls for effective adaptation. Even if the global average temperature can be kept below 2°C above the pre-industrial level, climate change consequences will occur, and Germany will have to adapt to these changes (Figures 03 and 04). Besides reducing greenhouse gas emissions, German climate policy therefore aims to limit the consequences of climate change which are already unavoidable by means of appropriate precautions and retroactive measures. Adaptation helps make the areas affected by the impacts of climate change more resilient. Adaptation measurements can include banning oil-fired heating systems in flood protection areas or establishing warning systems for heat and torrential rain. More heat-resistant materials can be used when building roads. Moreover, timely adaptation to climate change also reduces overall costs, because it avoids damages before they occur.

To ensure climate preparedness, it is important to predict the consequences of climate change as precisely as possible. To this end, the Federal Government's German Climate Preparedness Portal (KliVO)[9] pools central climate preparedness services through the provision of meteorological and climatological data. The KliVO also provides adaptation services to help the Federal States, districts and municipalities, as well as civil society and the private sector, cope with the consequences of climate change. For example, temperature and precipitation data, land-use plans and information on population trends enable urban planners to estimate where extreme heat or torrential rain could pose a risk to people and infrastructures.

Figure 04: **Consequences of climate change and adaptation measures**

Increased heat stress

Adaptation measures: creation of green corridors in cities, heat warning system for vulnerable groups, improvement of drinking water supply during hot periods.

Where: conurbations in Germany's warmer regions.

Increased risk of forest fires

Adaptation measures: creation of location-appropriate mixed forests, prevention of forest fires, effective forest fire fighting.

Where: regions with intensive forestry in Eastern Germany and highlands.

River flooding

Adaptation measures: restoration of natural watercourses and river meadows, establishment of water retention basins and infiltration areas.

Where: conurbations in the river valleys of the lowlands of Northern Germany, as well as the catchment areas of the Rhine and Danube.

Rising sea levels, increased swells, elevated risk of storm tides

Adaptation measures: development of climate, extreme weather and waterbody forecasts, raising embankments.

Where: coastal areas.

Torrential rainfall and flash floods

Adaptation measures: infrastructure resilient to climate change, optimisation of dams, storage and retention basins.

Where: conurbations in the North-western German lowlands, highlands and South-western German regions.

Impairment of water use due to increasing warming

Adaptation measures: reduced water extraction by the energy sector and industry.

Where: regions with hot and dry climates in Eastern Germany and the Rhine catchment area.

Changes in species composition and natural development phases

Adaptation measures: habitat optimisation for endangered species, reforestation, systematic consideration of the soil's climate regulating functions.

Where: seas and rural areas.

Source: BMU (2015)

Adaptation to climate change is being promoted at a local, national, European and global level. The German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie an den Klimawandel, or DAS) has been defining the political framework for adaptation to climate change, identifying its central goals and options for action since 2008.[10] The Adaptation Action Plan, published in 2011, the first DAS Progress Report in 2015 and the second Action Plan (APA II), which the Progress Report includes, have stipulated concrete measures for these objectives and options for action. The 2015 Monitoring Report and Vulnerability Analysis, which investigated Germany's potential exposure to climate change risks, provided key foundations for the Progress Report. The measures defined in APA II span the key areas of water, infrastructure, spatial planning and population protection, land, health and the economy. They range from intensive measures and research activities to legal requirements and technical rules. For example, watercourses and river meadows are to be returned to their natural states, and natural floodplains are to be created to mitigate flooding risks. The Federal Government will present a third Action Plan with a second Progress Report on the German Strategy for Adaptation to Climate Change in autumn 2020.

The 2019 Monitoring Report on the German Strategy for Adaptation to Climate Change shows how important a comprehensive policy is. The report shows that the average annual temperature in Germany has increased by 0.3°C in the last five years alone. The North and Baltic Sea levels have risen by over ten centimetres since 1981. There are also more and more hot days (> 30°C) and associated deaths, along with extreme weather events like storms, droughts and torrential rains, which cause billions of euros in damages. In the heat-wave years of 2003, 2006 and 2015, deaths increased statistically by 19,500 compared with the figures predicted for years without heat waves (Figure 03).

As many measures are implemented locally, municipalities play a key role in climate change adaptation. Cities and municipalities are particularly affected by the impact of climate change. Floods, urban heat islands, torrential rainfalls and storms endanger not only people and health but also municipal infrastructures like streets, sewage systems, public buildings and hospitals. Furthermore, municipalities provide key public services like public drinking water supply and wastewater disposal.

8.9 cm

The sea level of the North Sea has risen by 8.9 centimetres since 1981 (measured in Cuxhaven, Germany).

Municipalities receive support to deal with climate change at German and European levels. For example, the Federal Government funds adaptation measures through a number of funding programmes. Since 2011, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has been supporting local and regional global warming adaptation projects with up to 300,000 euros through the "Measures to Adapt to the Consequences of Climate Change" programme. In addition to this, a European adaptation strategy has been underway since 2013. The aim is to appropriately supplement national, regional and local efforts. To this end, it directly funds measures, such as developing adaptation strategies, both at the national and municipal level.

Adaptation to climate change is also being promoted at an international level. As early as the 1990s, the global community of nations committed to developing climate change adaptation measures in the context of the United Nations Framework Convention on Climate Change (UNFCCC). Since 2008, the Adaptation Fund has been financing measures in developing countries that are particularly affected by the adverse effects of climate change. The fund is also part of the Paris Agreement, in addition to the Kyoto Protocol. As part of the United Nations 25th Climate Change Conference in Madrid, Germany committed to donating a further 30 million euros to the Adaptation Fund. With that, Germany remains the biggest donor, having provided 310 million euros to date. As part of the International Climate Initiative (IKI), BMU helps particularly vulnerable countries and regions improve their ability to adapt to climate change impacts. From 2008 until the end of 2018, 120 projects in the adaptation support sector were funded with a total volume of 716 million euros.

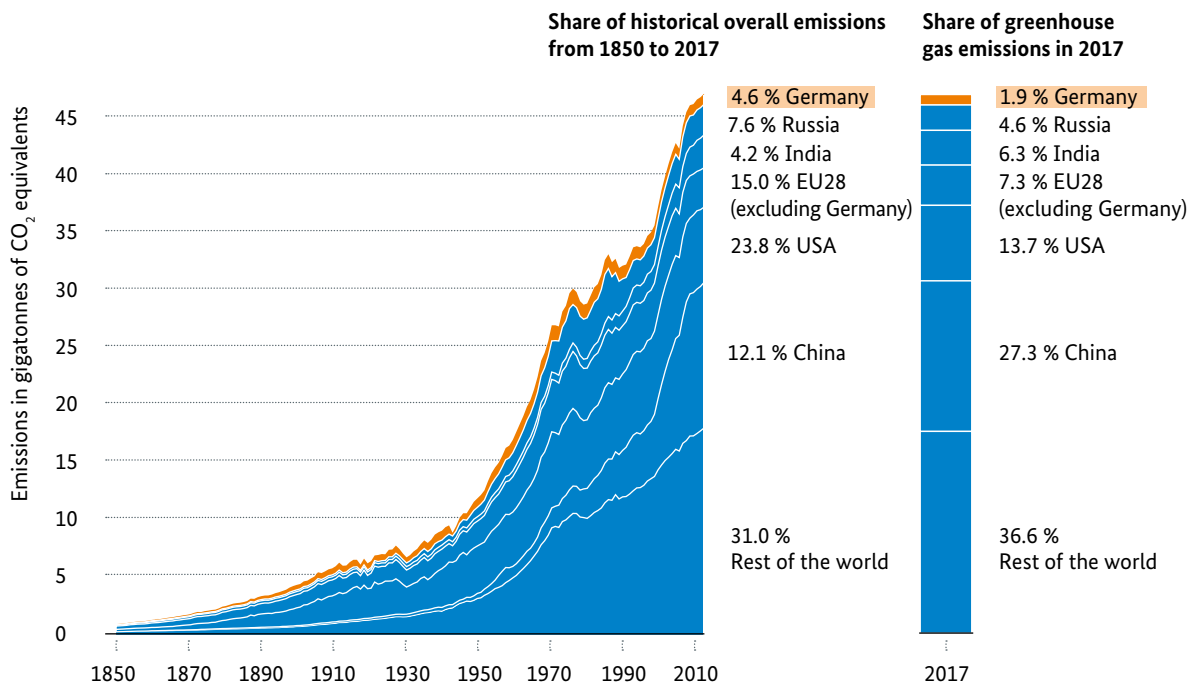
1.3 Global responsibility and opportunities for a sustainable future

Industrialised countries bear a particular responsibility for climate change. Since the start of industrialisation, the current industrialised countries have caused more than half of all greenhouse gas emissions. This total is based on the historic overall emissions caused worldwide between 1850 and 2018. In recent years, emissions from emerging nations, with China to the fore, have skyrocketed. This is due to the later onset of industrialisation, compared with the industrialised nations, and the associated increase in living standards. The United States of America (USA), the EU, China, Russia and India are currently the largest emitters of greenhouse gases worldwide (Figure 05).

Historically, Germany accounts for 4.6 per cent of greenhouse gas emissions. At 9.2 tonnes of CO_2, the per capita CO_2 emissions in Germany were almost twice the global average of 4.97 tonnes in 2017 (Figure 06). In light of its above-average emissions, Germany has a particular responsibility to reduce its own emissions and combat the stress on humans and the environment.

Germany takes on responsibility for climate action at a national and international level. The Federal Government is therefore aiming to achieve the ambitious goal of greenhouse gas neutrality by 2050. To reach this goal, the Climate Action Plan 2050 was supplemented in 2019 with the Climate Action Programme 2030, with measures in all sectors, and the Climate Change Act. The Climate Change Act, which entered into force in December 2019, defines how Germany is to reach its climate targets by 2030. The Act specifies fixed emission targets for each sector and a verification mechanism. (see Section 2.3 for more information on the Climate Action Programme 2030 and the Climate Change Act).

Figure 05: **Global greenhouse gas emissions**



Source: PIK (2019)

9.2 tonnes

German per capita CO_2 emissions are 9.2 tonnes, or almost twice the global average.

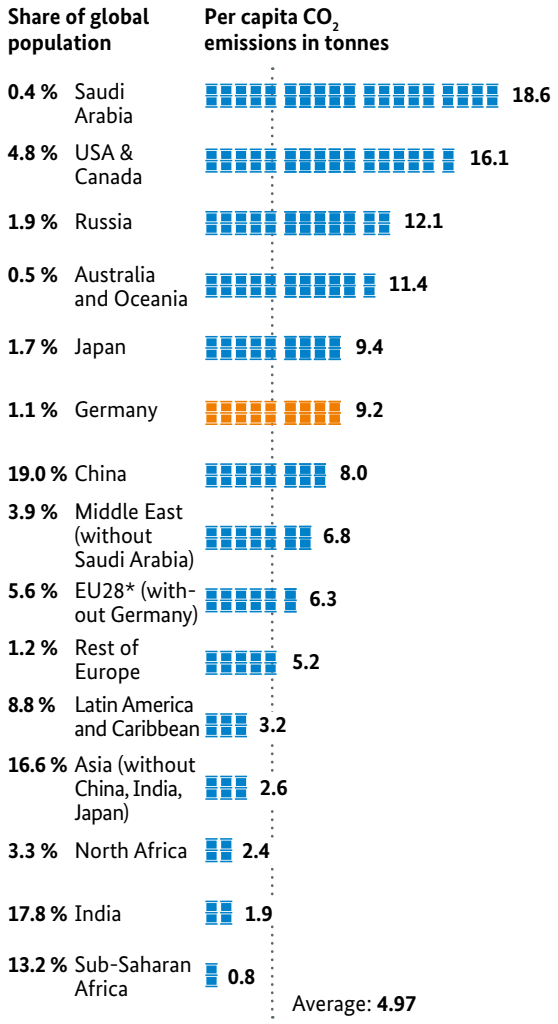
Climate action is also one of the targets of the United Nations 2030 Agenda for Sustainable Development, which the Federal Government has adopted. Sustainable Development Goal 13 requires that urgent measures be taken to combat climate change and its impacts. In 2015, the global community agreed for the first time on a universal catalogue of fixed targets, including all dimensions of sustainability, in the Sustainable Development Goals.

Germany holds a key position in view of compliance with climate action targets. With its successful economy, Germany is a high-tech industrial country with a high percentage of energy-intensive industries. Successful climate action in Germany can serve as a role model for other countries. The energy transition is an important example of this – Germany is leading the way and building expertise. It is with great interest that the international community has been watching the increasing share of renewable energy sources in the electricity mix.

A growing share of the overall greenhouse gas emissions occur outside Germany. This is why Germany is eager to share its own experience with others. Additionally, it is providing financial support for climate action measures. Besides its commitment to international climate funding instruments, Germany has financed over 700 climate action projects around the world with a total of 3.9 billion euros as part of its International Climate Initiative (IKI) since 2008 (see Section 2.1 for more information on German climate finance).

Germany is also involved in energy partnerships and energy dialogues with over 20 countries to promote the international sharing of lessons learned on the energy transition. Partner countries include Algeria, Brazil, China, India, Morocco, Russia, South Africa, the USA and the United Arab Emirates. The aim of the energy partnerships is to share own experiences and benefit from lessons learned by other partner countries through workshops, working groups and study trips. These focus thematically on expanding renewable energy, increasing energy as well as developing and integrating a regulatory framework to promote the energy transition.

Figure 06: **Share of the global population and per capita CO_2 emissions by selected region in tonnes (2018)**



*Including Monaco, San Marino, Andorra

Source: EDGAR (2019)

2. Climate targets and instruments

Summary

In December 2015, the international community of nations passed the Paris Agreement, agreeing to limit global warming to significantly under 2°C and to pursue efforts to keep it below 1.5°C. However, the measures to restrict greenhouse gas emissions announced under the Climate Agreement are far from sufficient to fulfil this objective. As a result, all parties must submit additional, ambitious measures in 2020.

The European Union (EU) is committed to making Europe greenhouse gas-neutral by 2050. It has undertaken to reduce the EU's greenhouse gas emissions by at least 40 per cent by 2030 compared with 1990. To combat climate change, the European Commission is relying on EU-wide measures like the EU Emissions Trading System (EU-ETS) and binding Nationally Determined Contributions (NDCs) by 2020 and 2030, in addition to formulating targets.

In Germany, by 2030, greenhouse gas emissions are to be reduced by at least 55 per cent compared with 1990. The Climate Action Programme 2030 passed in 2019 includes measures for all sectors and cross-sector instruments. The core element of the programme is introducing national CO_2 pricing in the heat and transport sectors. The 2019 Climate Change Act determines that Germany will be greenhouse gas-neutral by 2050 and establishes a fixed legal framework for binding attainment of German climate targets.

2.1 International climate policy

International climate policy is based on the United Nations Framework Convention on Climate Change (UNFCCC). Launched in Rio de Janeiro in 1992, it has since been ratified by 197 nations and parties, including the European Union. Its goal is to mitigate human-made climate change. To achieve that, a UN Climate Change Conference, or Conference of the Parties (COP), has been held annually since 1995.

In the Kyoto Protocol, industrialised countries agreed binding greenhouse gas reduction targets under international law for the first time. The agreement, passed in 1997, entered into force in February 2005. In phase I, Germany undertook to reduce its own greenhouse gas emissions by 21 per cent by 2012, compared with 1990. At the UN Climate Change Conference in Doha in 2012, 144 countries agreed to continue the Protocol in a second phase until 2020. For phase II, Germany voluntarily set itself the goal of reducing its emissions by 40 per cent by 2020. However, many emerging countries, such as India and China, did not have to specify any binding emission reduction targets under the Kyoto Protocol.

The Paris Agreement was concluded in December 2015. It aims to limit average global warming to significantly under 2°C and to pursue efforts to keep it below 1.5°C. The Agreement was signed by 195 countries and the EU and ratified by 187 parties. It has been in force since December 2016. All parties are obligated to define their own Nationally Determined Contributions (NDCs) for greenhouse gas reduction by 2020; 186 parties have already submitted their first NDCs, while three parties have presented their second, revised NDCs. From 2020 on, NDCs must be updated every five years, and the updated NDCs must be more ambitious than their predecessors. The EU has developed a common NDC with its Member States. Accordingly, the NDCs play a key role in the Paris Agreement, as they reflect the parties' ambitions and highlight the gap to reaching the targets of the Paris Agreement.

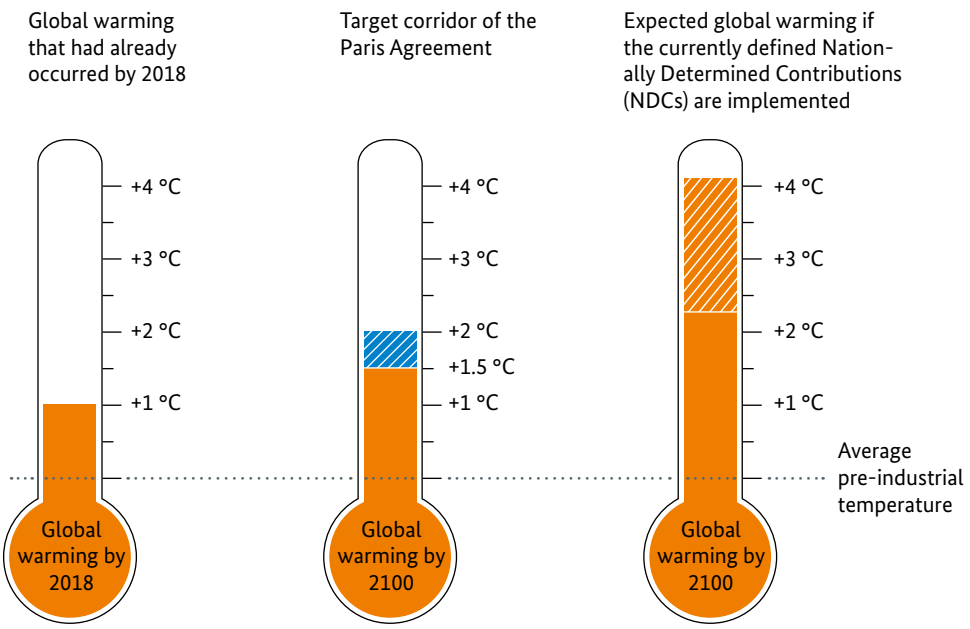
The measures announced to date by states under the Paris Agreement are not sufficient to reach the 2°C target. Until 2030, they actually result in 50 per cent higher greenhouse gas emissions than required to prevent a global increase in the average temperature by 2°C compared with 1990.[11] A development of this kind would result in a global warming of 3°C by 2100 (Figure 07). All parties must therefore raise their ambitions and upgrade the measures they have announced.

Climate financing plays a key role in the implementation of the Paris Agreement. The industrialised countries have undertaken to mobilise 100 billion dollars from public and private sources every year between 2020 and 2025 to implement climate action measures in developing and emerging countries. In total, Germany earmarked over seven billion euros for climate funding in 2018. Almost half of this, more than 3.2 billion euros, was provided by the German National Development Bank (Kreditanstalt für Wiederaufbau, KfW) and the German Development Corporation (Deutsche Entwicklungsgesellschaft, DEG); 468 million euros were provided in the form of mobilised private climate finance. The remainder, over 3.3 million euros, was financed from German budget funds. The share of government funding will increase to roughly 4.1 billion euros by 2020, which is more than double the amount provided in 2014. The funds are used for the Global Environment Facility, the Green Climate Fund (GCF) and the Adaptation Fund.

Via the International Climate Initiative, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) also supports specific projects in developing and emerging countries. It promotes projects worldwide that aim to reduce greenhouse gases, adapt to the impacts of climate change and preserve natural carbon sinks. The focus is on reducing emissions from deforestation and forest degradation, as well as preserving biodiversity. Between 2008 and 2019, the International Climate Initiative has included over 700 projects and programmes with a volume of 3.9 billion euros in its funding. Germany is also involved in a series of international initiatives, such as the Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism, the Bonn Challenge and initiatives for reforestation and restoration of forest ecosystems.

The Federal Government is a member of the global NDC partnership. In this initiative, it supports developing and emerging countries in implementing and updating their NDCs. Since the start of this partnership, the Federal Ministry for Economic Cooperation

Figure 07: **Ambition gap between the Paris Agreement and current NDCs of the contracting parties**



Source: Navigant, New Climate Institute, Climate Analytics (2020)

and Development (BMZ) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) have provided support totalling roughly 500 million euros. The new Climate Action Enhancement Package to support NDC updates receives funds totalling 17 million euros (BMU contribution five million euros). Both BMZ and BMU also support major multi-country projects to implement NDCs that can be aligned with the support needs of the partner countries as part of the NDC Partnership.

i

International protection, preservation and restoration of forests

As carbon sinks, forests play a key role in preserving the climate. According to United Nations (UN) estimates, in 2005, forests stored more carbon than contained in the entire atmosphere. Roughly 20 per cent of global greenhouse gas emissions are caused by deforestation and damage to forests. As a result, Germany supports the implementation of the REDD+ framework, which aims to minimise emissions from deforestation and forest damage. For example, it aims to reduce the conversion of tropical forests to agricultural land. In the Bonn Challenge, initiated by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), countries undertake to restore 150 million hectares of forest by 2020. These commitments are to increase to 350 million hectares by 2030. Germany also supports the African Forest Landscape Restoration Initiative, the World Bank's ProGreen programme and the Central African Forest Initiative. United Nations Sustainable Development Goal 15 additionally promotes sustainable forest management.

2.2 European climate policy

Climate action is a political priority for the European Union. The EU focuses on overarching targets, EU-wide measures and binding climate targets to combat climate change. Germany has taken on an active role in implementing and developing the European climate policy.

The EU pursues the target of achieving climate neutrality by 2050. The European Council unanimously supported this target at its meeting in December 2019. This commitment can be traced back to the European Commission initiative entitled "A Clean Planet for All", which was presented at the end of 2018. The initiative lays out a long-term strategic vision to reach a prosperous, modern, competitive and climate-neutral economy by 2050. With the new long-term climate target, the EU is bolstering planning certainty, both for the economy and for society. Furthermore, the EU and all other parties to the Paris Agreement are called upon to submit a long-term climate action strategy in 2020. In spring 2020, the Croatian Council Presidency communicated the new EU target of attaining climate neutrality by 2050 to the United Nations. With its Climate Action Plan 2050, Germany formulated a superordinate reduction strategy in 2016.

In January 2020, the European Commission presented an ambitious sustainability strategy for Europe, called the European Green Deal. The core of the strategy is an EU Climate Change Act to define the climate neutrality target by 2050 with a legally binding effect. This also includes reviewing and potentially updating current greenhouse gas reduction targets. The Green Deal also contains measures for all sectors that are intended to contribute to the European climate action targets. The Commission is now implementing these measures step by step.

The European Green Deal sets new strategic incentives in many key areas. A new plan for a smart integration of the electricity, gas and heating sectors will be presented as early as 2020. This is accompanied by an initiative to better harness the potential of offshore wind energy in the EU. In spring 2020, a new Circular Economy Action Plan is envisaged, which is to form part of a comprehensive EU industrial strategy. The aim is to reduce material consumption and increase the re-use and recycling of products. Decarbonisation and modernisation of energy-intensive industries, like steel and cement production, play a key role for the new industry strategy. The Commission announced that it would present a proposal to promote CO_2-free steel generation by 2030. In the buildings sector, the EU-wide renovation rates for public and private buildings should at least be doubled. These and other measures will contribute to improving the overall efficiency of buildings in the EU. In future, the climate friendliness of buildings is to be ensured to a greater extent than before, and the regulations on the overall efficiency of buildings are to be implemented more strictly.

A new agricultural strategy aims to make the agricultural system greener and healthier. This includes plans to significantly reduce the use of fertilisers and to assess the compatibility of the EU's Common Agricultural Policy (CAP) with the Green Deal in the course of its upcoming reform. The EU also plans to spur the reforestation and restoration of damaged and decimated forests as part of a new forestry strategy to achieve the target of climate neutrality by 2050. As part of the Green Deal, emissions in the transport sector are to be reduced by 90 per cent by 2050. Corresponding objectives include the provision of one million public charging stations throughout Europe by 2025. The share of rail and marine freight transport is also to be increased.

Horizon Europe, the new research and innovation programme, is to contribute comprehensively to the Green Deal with a budget of 100 billion euros for the next seven years (2021 to 2027) ; 35 per cent of the EU research funding alone is earmarked for climate-friendly technologies. To help mitigate the social and economic effects of the measures introduced, a financial compensation mechanism will be set up to ensure that the energy transition is equitable. This way, dedicated support can be offered to particularly affected regions and sectors. In total, at least 100 billion euros are available and will be mobilised in three funding lines: a new fund for an equitable energy transition, which is to generate investments of 30 to 50 billion euros, the InvestEU programme to mobilise a further 45 billion euros, and additional funds from the European Investment Bank (EIB) to incentivise investments with a total of 25 to 30 billion euros. Affected regions also receive technical support to manage environmental protection and climate action investments.

The EU has already committed to reducing its greenhouse gas emissions by 20 per cent by 2020 and by at least 40 per cent by 2030, compared with 1990. The new Climate and Energy Package passed by the EU heads of state and government in 2007 contained the first binding EU targets to reduce greenhouse gas emissions by 20 per cent compared with 1990, to increase the percentage of renewable energy sources in the final energy consumption to 20 per centand to improve energy efficiency by 20 per cent by 2020. For the period from 2021 to 2030, these EU-wide targets have been extended and expanded accordingly: the framework for climate and energy policy until 2030, passed in 2014, prescribes an EU-wide reduction of greenhouse gas emissions by at least 40 per cent compared with 1990. It also foresees expanding the share of renewable energy sources in final energy consumption to at least 32 per cent, and increasing energy efficiency by a minimum of 32.5 per cent, measured against primary energy consumption. In its NDC, the EU has also made an international commitment to reducing its greenhouse gas emissions by 2030, in accordance with the target stated above.

Member States must submit integrated National Energy and Climate Plans (NECPs) for the period from 2021 to 2030. In their NECPs defined by the EU Governance regulation, Member States provide comprehensive information on their national contributions and measures to achieve the EU energy and climate targets by 2030. This is intended to improve the coordination of European energy and climate policies, and to ensure compliance with the EU 2030 targets. All EU Member States were required to send a draft of their NECPs to the European Commission by the end of 2018. Final NECPs were to be submitted to the European Commission by the end of 2019. The Member States will report on progress towards reaching the chosen targets every two years thereafter.

As part of effort sharing, the EU Emissions Trading System and emission reduction targets are key components of the EU climate policy. The EU Emissions Trading System (EU-ETS) covers most emissions in the energy sector and industry, including inner-European aviation (since 2012). Since 2013, emissions trading has also included nitrous oxide and perfluorinated hydrocarbons, in addition to CO_2. It accounts for roughly 40 per cent of all EU greenhouse gas emissions.[12] For activities outside the Emissions Trading System, the Effort Sharing Decision (ESD) stipulates binding emission targets for each EU Member State for the period until 2020. The EU Effort Sharing Regulation (ESR) addresses the period until 2030. Both primarily cover the transport, buildings and agriculture sectors and small industrial plants, which make up roughly 58 per cent of all EU greenhouse gas emissions combined. From 2021 on, the land use, land use change and forestry (LULUCF) regulation, which entered into force in 2018, will additionally integrate the carbon footprint of forests and soil in the European framework for climate action.

> *"We can and must succeed in making Europe the first climate-neutral continent by 2050"* *Ursula von der Leyen, President of the European Commission*

Under the EU Emissions Trading System, companies can only cause emissions for which they hold emission allowances. Based on the EU's long-term climate and energy targets, the supply of allowances available on the market is limited. Market participants must submit one allowance for every tonne of greenhouse gas emitted. This mechanism provides an economic incentive to reduce emissions. Market participants are free to trade allowances amongst themselves. This way, a market is created in which the price for an emission allowance is based on the supply of emission rights and market participants' demand. Emissions of greenhouse gases are avoided where the costs are lowest.

The EU Emissions Trading System sets binding emission reduction targets. To make their contribution, sectors included in the EU-ETS must reduce their emissions by 21 per cent by 2020 and by 43 per cent by 2030, compared with 2005 levels (Figure 08). In 2018, the EU-ETS emissions from stationary plants had already been reduced by 29 per cent compared with 2005.[13] However, emissions trading initially failed at large to achieve the required effect. This was due to a steadily increasing surplus of emission allowances and the resulting low incentives for market stakeholders to bring their emissions down. Initially, an excessive number of allowances had been issued, and low-cost allowances had been purchased from non-European countries.

The reform of the EU Emissions Trading System in February 2018 increased the prices of emission allowances. With the introduction of a market stability reserve in 2019, excess emission allowances have been gradually transferred into a reserve inventory. From 2023 on, the permitted volume of this reserve will be limited so that all remaining allowances will be permanently withdrawn from the market. The scarcity of the freely available emission rights is intended to enhance the price signal of emissions trading in the long term. Since the reform was announced, the price for emission rights has quintupled from an average of five euros per tonne of CO_2 in 2017 to roughly 25 euros in early 2020.[14] One example of this measure's impact is that since 2017, many modern, low-emission gas and steam power plants have become more competitive than the emission-intensive hard coal-fired power plants.

i

The European Climate Initiative (EUKI) promotes climate action cooperation within the EU.

The priority is to share knowledge and experience and to foster the dialogue on climate policy between local stakeholders in the various Member States, especially in Central, East and South-East Europe. In this way, the funding instrument launched by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) helps implement the Paris Agreement on the ground. Since its introduction in 2017, it has funded a total of 86 projects. In the annual EU-wide competitions for ideas, non-government organisations, authorities, non-profit companies as well as scientific and educational institutions can propose their forward-looking climate action projects for funding. A wide range of projects have been financed, from training young "Energy Scouts" at companies, for example in Hungary and Greece, to the renaturation of moors in the Baltic nations and the scientific assessment of EU climate funding flows.

40 %

Over 40 per cent of global public funding of climate action projects is provided by the EU.

The emission reduction targets outside the EU Emissions Trading System are distributed across the individual EU Member States. With its Effort Sharing Decision, the EU has set itself the goal of reducing greenhouse gas emissions by just under ten per cent throughout the EU by 2020 in the sectors not included in the EU Emissions Trading System compared with 2005. The EU Effort Sharing Regulation from 2018 defines an EU-wide emission reduction of 30 per cent compared with 2005 for the subsequent period until 2030. Member States must make various contributions to the EU-wide targets, depending primarily on their economic output per capita. For the period until 2020, targets for Member States range between a reduction of 20 per cent and a permitted increase of 20 per cent (Figure 08). Until 2030, the range foresees a reduction of greenhouse gas emissions of between zero and 40 per cent. Germany must reduce its emissions in the sectors concerned by 14 per cent by 2020 and 38 per cent by 2030, compared with 2005. If a Member State misses its national reduction goal for 2020 or 2030, it can take unused emission allowances from previous years or purchase them from Member States that have overfulfilled their targets.

Attainment of the EU-wide targets by 2020 is highly likely for the sectors outside the EU Emissions Trading System. For example, the overall emission reduction target for 2020 of ten per cent compared with 2005 has already been fulfilled. However, additional efforts are necessary to reach the target for 2030, as the current climate strategies and measures at national and European levels are probably only sufficient to reduce emissions by 20 per cent compared with 2005.[15]

The target achievement status of individual Member States shown in Figure 08 can be read as follows: the countries that have to achieve a percentage reduction of their greenhouse gas emissions by 2020 already reached their targets in 2018 if the target point (orange) is to the left of the target bar (blue). The countries that are allowed to attain a percentage increase of their greenhouse gas emissions by 2020 already fulfilled their

Figure 08: **EU climate targets, climate action instruments and status of target achievement (2018)**

EU Climate Package 2020

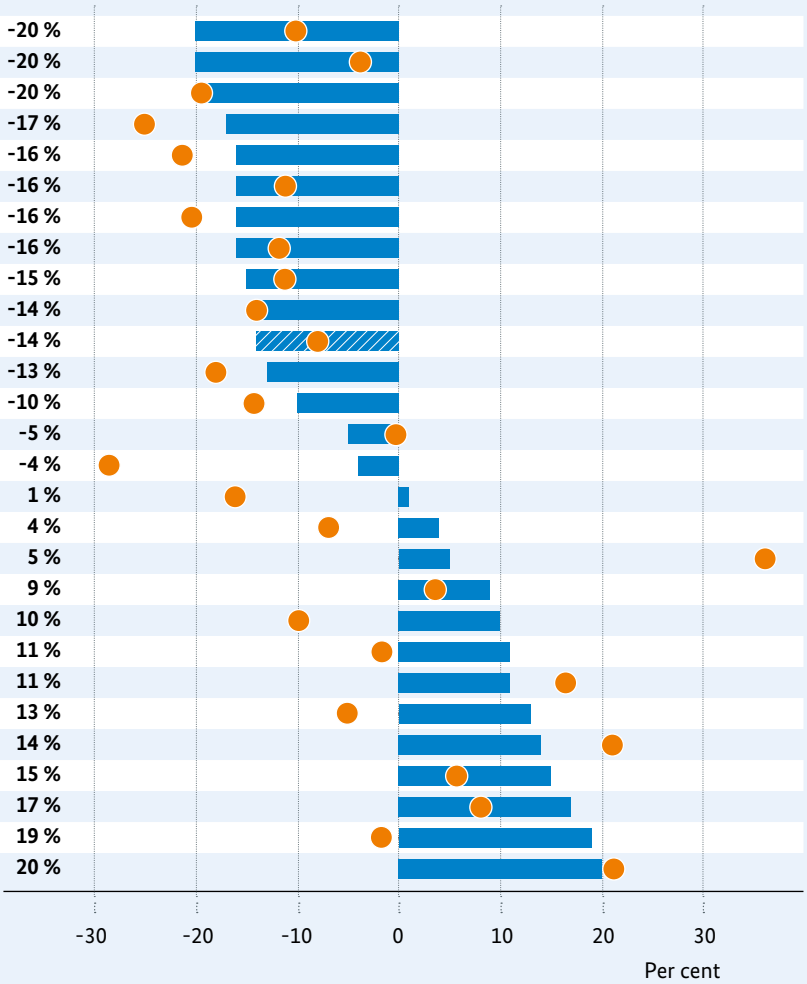
20 % emissions reduction compared with 1990
(corresponds to -14 % compared with 2005)

EU Emissions Trading System
-21 % compared with 2005

Effort sharing
-10 % compared with 2005

Distribution of the effort sharing target to the 28 Member States and status of target attainment (as a percentage compared with 2005)

	Status quo 2018*	2020 target
Luxembourg	-9.9 %	-20 %
Ireland	-3.6 %	-20 %
Denmark	-19.2 %	-20 %
Sweden	-24.8 %	-17 %
United Kingdom	-21.2 %	-16 %
Austria	-10.9 %	-16 %
The Netherlands	-20.3 %	-16 %
Finland	-11.5 %	-16 %
Belgium	-11.1 %	-15 %
France	-13.8 %	-14 %
Germany	-7.7 %	-14 %
Italy	-17.8 %	-13 %
Spain	-14.1 %	-10 %
Cyprus	0.0 %	-5 %
Greece	-28.3 %	-4 %
Portugal	-16.0 %	1 %
Slovenia	-6.8 %	4 %
Malta	36.4 %	5 %
Czech Republic	3.9 %	9 %
Hungary	-9.8 %	10 %
Croatia	-1.1 %	11 %
Estonia	16.7 %	11 %
Slovakia	-4.8 %	13 %
Poland	21.1 %	14 %
Lithuania	6.0 %	15 %
Latvia	8.2 %	17 %
Romania	-1.6 %	19 %
Bulgaria	21.3 %	20 %

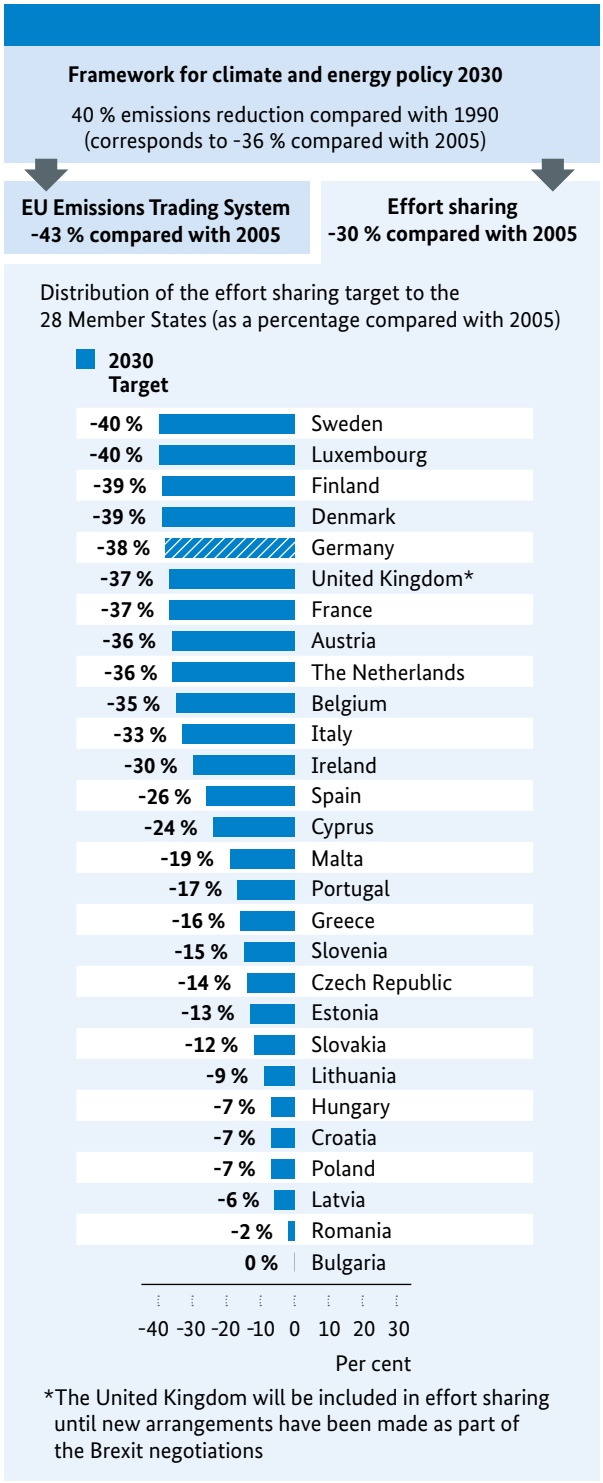


*Estimate

Sources: European Commission (2018), EEA (2019)

targets in 2018 if the target point (orange) is within or to the left of the target bar (blue). In 2018, ten Member States were still below their emission reduction targets for 2020, including Germany.

Some European countries are taking successful climate action. Besides sector-specific measures, some countries, including the United Kingdom (UK), France and Sweden, have also passed cross-sector climate change acts. For example, the UK Climate Change Act



(CCA) passed in 2008 defines an emission reduction of 80 per cent by 2050, compared with 2005, plus CO_2 budgets for five-year periods. In 2019, the UK government set itself the target of achieving greenhouse gas neutrality by 2050. Since it was passed, the law has contributed to a significant reduction in the UK's greenhouse gas emissions.

From 2021 on, any deterioration of the carbon footprint from land use, land use change and forestry (LULUCF) must be compensated in full. In the LULUCF sector, emissions can be mitigated via carbon sinks, which store CO_2. Under the LULUCF regulation, every EU Member State compares the CO_2 effectively stored by forests and soil with the comparison scales defined in the regulation. A reduction of the amount of CO_2 stored, compared with the reference standard, results in debits, and an increase results in credits. In the period from 2021 to 2030, Member States must ensure that their balance includes more credits than debits, so that the climate balance of the LULUCF sector does not deteriorate in overall terms. Debits must be compensated via additional climate action within the land use sector or in other sectors outside the EU Emissions Trading System. To some extent, credits may also be transferred to sectors that are subject to the EU Effort Sharing Regulation.

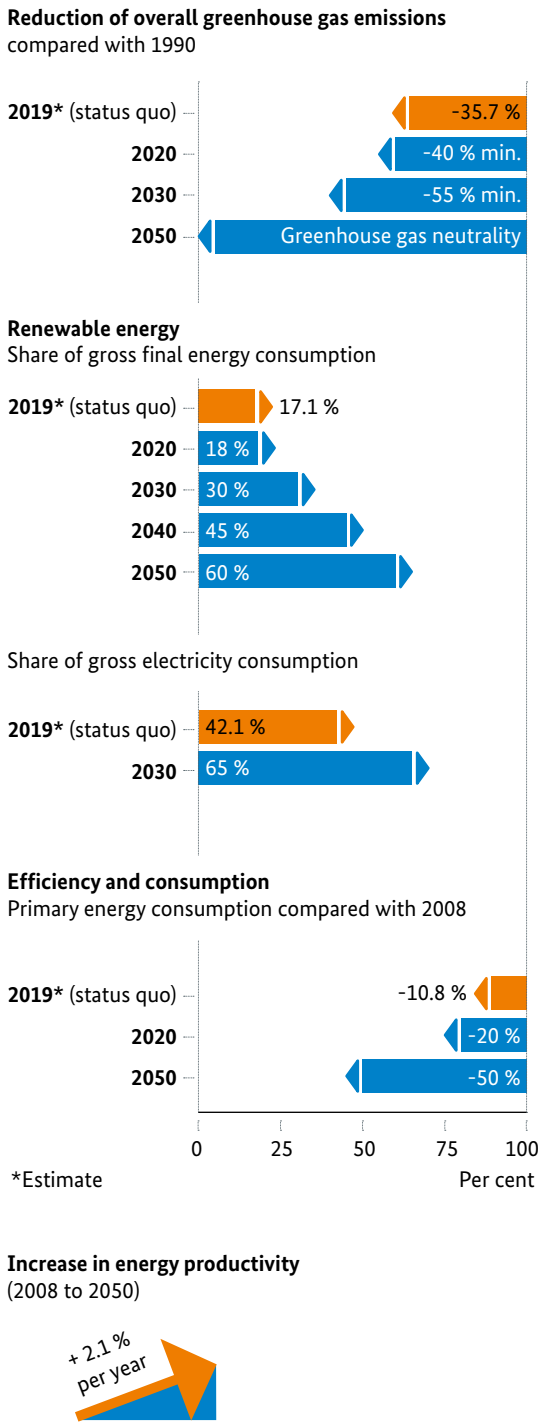
2.3 National climate policy

Germany lives up to its international responsibility as an industrial nation with ambitious climate targets. Germany aims to be greenhouse gas-neutral by 2050. As a first step, greenhouse gas emissions are to be reduced by at least 55 per cent by 2030, compared with 1990 (Figure 09). Offering guidance for strategic decisions, the sector targets set out in the Climate Change Act for the period until 2030 are milestones on the road to greenhouse gas neutrality. In the energy sector, greenhouse gas emissions are to be reduced by 62 per cent compared with 1990, in the buildings sector by 67 per cent, in the transport sector by 42 per cent, in the industrial sector by 51 per cent and in the agricultural sector by 36 per cent (see also Section 3). While no reduction target has been specified for the LULUCF sector, it must be preserved as a carbon sink (see Spotlight 2020 on page 24 for more information on the Climate Change Act).

The Climate Action Programme 2030 includes measures for all sectors and cross-sector instruments. Passed by the Federal Cabinet in October 2019, this law stipulates the introduction of a national emissions trading system from 2021 as its most important cross-cutting measure. It allocates a gradually increasing price to emissions from the combustion of heating oil, natural gas, petrol and diesel to make more climate-friendly alternatives more attractive for future purchase and investment decisions in the heating and transport sectors (see also Spotlight 2020). Moreover, the Climate Action Programme 2030 defines a wealth of measures in the energy, industrial, buildings, transport, agriculture, forestry and waste management sectors to achieve the climate targets in every sector by 2030. For instance, coal-based electricity generation is to be reduced and phased out by 2038 at the latest. There are also plans to increase the expansion of renewable energy to 65 per cent of electricity consumption by 2030, and to increase investments in local public transport, cycle paths and rail transport. All legislative measures to implement the programme are to be passed in good time.

The Climate Change Act is the legal framework for achieving the German climate targets. Defining the target of full greenhouse neutrality by 2050, it includes annual emission reduction targets for individual business sectors for the period between 2020 and 2030.

Figure 09: **Federal Government energy and climate targets**



Further information on the Federal Government's energy and climate targets can be found in the data appendix on page 65.

Sources: BMWi (2010), Federal Government (2019a)

The act also establishes an assessment and recalibration system that takes immediate action if the existing measures are found insufficient to achieve the climate targets. If it becomes apparent that a sector will miss its emission reduction target, the ministry with primary responsibility for that sector must submit further measures as part of an immediate action programme. Emission budgets can only be reallocated between sectors to compensate for missed targets if the emission reduction target of the respective year can still be reached in overall terms.

Energy efficiency and renewable energy sources are the cornerstones of emission reduction in Germany. The measures in the Climate Action Programme 2030 build on existing funding programmes in both areas, which they continue systematically. By 2019, energy efficiency-increasing measures had reduced primary energy consumption by 11 per cent, compared with the base year 2008.[16] The aim is to achieve further improvements, with the final goal of reducing primary energy consumption by 20 per cent by 2020 and 50 per cent by 2050, compared with the base year. Germany has set itself the additional target of increasing the share of renewable energy sources to 30 per cent in gross final energy consumption and to 65 per cent in gross electricity consumption. The intermediate target for 2020, measured against the gross final energy consumption, is an 18 per cent share of energy from renewable energy sources (Figure 09). This figure had reached 17.1 per cent by 2019.[17]

Climate action requires measures and financial aid at a local level. The National Climate Initiative (NKI) is an important instrument for the promotion of local climate action. Since its launch in 2008, this initiative has reduced emissions by over 28 million tonnes of CO_2 equivalents (gross throughout the effective duration). This reduction results from over 32,500 investment and non-investment measures, funded with a total volume of roughly 1.07 billion euros, in turn triggering total investments of over 3.5 billion euros. In this way, the funds deployed mobilise far higher investments in climate action and help municipalities, companies and consumers make their individual contributions.

54
billion euros

The Federal Government will provide 54 billion euros between 2020 and 2023 to implement the measures in the Climate Action Programme 2030.

The projects funded span a broad spectrum of climate action measures. For example, the NKI helps cities, municipalities and districts draw up climate action concepts or manage their energy supply and demand. The initiative also funds the transition to LED technology for street lighting, as well as investments in the cycling infrastructure. Since 2008, the National Climate Initiative has also been supporting innovative climate action projects for advice and information, for capacity building and for the sharing of lessons learned. Further activities include climate-action related networking and qualification support for companies, consumers, municipalities and educational institutions. Measures under the German air conditioning and cooling directive include investment measures to promote climate action through cooling and air conditioning systems. This benefits supermarkets, bakeries and butcher shops with cold rooms or production rooms, which require refrigeration. In 2019, funding was expanded to include vehicle air conditioning systems in buses and trains that use CO_2 as a coolant.

> *"The Climate Change Act will fundamentally improve the Federal Government's cooperation in the field of climate action. From now on, all ministries are climate action ministries."* *Svenja Schulze, Federal Minister for the Environment, Nature Conservation and Nuclear Safety*

Spotlight 2020

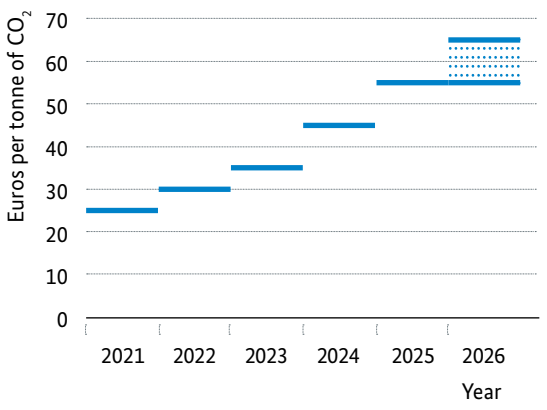
The Climate Package: Climate Action Programme 2030, the Climate Change Act and national fuel emissions trading

In October 2019, the Federal Government agreed on the Climate Action Programme 2030, followed by the entry into force of the Climate Change Act in December 2019. Both instruments are intended to help Germany achieve its climate targets for 2030. They also define the target of greenhouse gas neutrality for 2050. While the Climate Action Programme 2030 contains measures for all sectors, the Climate Change Act forms the legal framework for Germany's future climate policy. It ensures that emission reductions are predictable and climate targets can be reliably met. For the first time, it also prescribes legally binding climate targets with annually decreasing greenhouse gas budgets for every sector.

The Federal Chancellor initiated the Climate Action Cabinet Committee (Climate Cabinet) in spring 2019. Initially, the Climate Cabinet was to prepare decisions of the Federal Government on all laws and measures necessary to reach the target for 2030. In future, the Climate Cabinet will assess the effectiveness, efficiency and purposefulness of the measures taken. On 20 September 2019, it submitted key elements for the Climate Action Programme 2030, which were passed by the Federal Cabinet on 25 September. The Climate Action Programme 2030 follows up on the key elements and measures proposed by the competent ministries and passed by the Federal Cabinet on 9 October.

The Climate Action Programme 2030 pursues a comprehensive, three-pronged approach comprising regulatory law, price incentives and financial support. It follows the guiding principle of enabling Germany as an industrial nation to comply with the climate targets in an economically sustainable and socially equitable manner. The programme's measures pave the way for climate-friendly behaviour and climate-friendly investments. To this end, the government will provide 54 billion euros of funding in the next four years alone.

Figure 10: **Planned price path for national emissions trading until 2026**



Source: BMU (2020)

National CO_2 pricing is an important element of the programme. From 2021, the Federal Government is establishing a national emissions trading system which assigns gradually rising prices to emissions from the combustion of fuels that were not previously subject to the EU-ETS (Figure 10). Participants in this system generally include all stakeholders who deal in fuels and are subject to energy tax. For crude oil products, these are largely the dealers and producers; for natural gas, stakeholders primarily include the suppliers. From 2021 to 2025, allowances will be issued at annual fixed prices. This reliable pricing will enable citizens and companies to prepare for the way ahead and incorporate CO_2 pricing in their future purchase and investment decisions. From 2026 on, the allowance price will be determined by the market after initially being maintained within a price corridor. In 2025, a decision will be made on the continuation of a price corridor for the period from 2027 on. The pricing of greenhouse gases aims to make climate-friendly alternatives less expensive in future while increasing prices for more harmful options moderately but steadily. This is intended to encourage citizens to choose a climate-friendly product when buying their next car or heating system, for example. Income from CO_2 pricing will be invested fully in climate action measures, or returned to citizens by way of a financial relief. Much of the income will be used to lower electricity prices, for example reducing the shared contributions under the Renewable Energy

Sources Act (EEG) annually, in line with the rising pricing path.

The Climate Action Programme 2030 contains measures for the individual sectors. It incorporates the energy, industrial, buildings, transport, agriculture, forestry and waste management sectors (Figure 11). It also contains cross-sectoral measures.

The Climate Change Act provides the legal framework for the Climate Action Package. The Climate Change Act, which entered into force in December 2019, stipulates legally binding national climate targets for the first time. Extending to 2030, these targets address each individual economic sector and apply to both the present and future Federal Governments. By defining sector targets broken down by year from 2020 to 2030, it stipulates the annual emission reductions that individual sectors must contribute. Based on the law, targets can be defined by statutory elements for other years. In addition to this, the act defines greenhouse gas neutrality by 2050 as a long-term goal with a legally binding effect for German climate policy.

The Climate Change Act creates responsibility and transparency. By defining the annual sector targets (Figure 14), target attainment becomes reliable and predictable, as it has been given the standing of a law for the first time. It has been clearly defined how the Federal Government needs to take action if targets are not attained. The ministries primarily responsible for the respective areas are expressly given responsibility for meeting the emission reduction goals in their respective sectors. Each year, the Federal Environment Agency (UBA) publishes the emissions trend estimate from the previous year, which is assessed by an independent council of experts. If a sector fails to meet its target, corrective action must be taken immediately by means of an immediate action programme.

Figure 11: **Selected measures of the Climate Action Programme 2030 by sector**

Energy

- Phase-out of coal-based electricity per the recommendations of the Commission on Growth, Structural Change and Employment
- Expansion of renewables to 65 per cent of gross electricity consumption by 2030
- Development and modernisation of CHP plants
- Convert more and more heating networks to renewable energy sources and inevitable waste heat
- Real laboratories of the energy transition
- Energy Efficiency Strategy 2050 (EffSTRA)
- Energy transition flanking measures

Transport

- Increased funding for local public transport, cycle paths and rail
- Cheaper rail tickets, more expensive flight tickets
- Promotion of electric mobility
- CO_2-specific reform of motor vehicle taxes

Industry

- Investment programme for energy efficiency and process heat from renewable energy sources
- Competitive tenders for energy efficiency
- Industrial decarbonisation support programme

Buildings

- Tax incentives for energy building refurbishment
- Heating replacement support programmes
- No new oil-fired heating systems from 2026 on
- Developing energy standards through regulatory law

Agriculture and LULUCF

- Implementation and execution of the Fertilisation Regulation
- More funding for organic farming
- Aid for soils, forests and moors to ensure their climate regulating function

Waste

- Improvement of landfill aeration

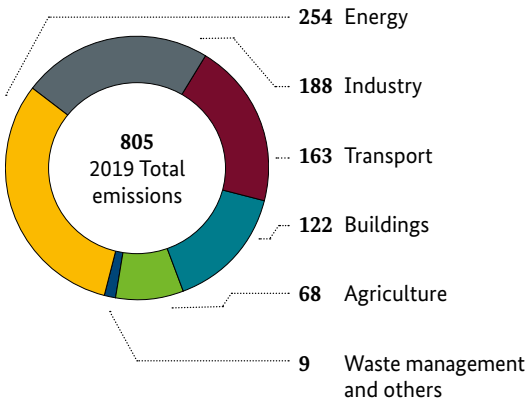
Source: Federal Government (2019b)

3. Emission trends and areas of action in the sectors

Summary

According to Federal Environment Agency estimates, Germany emitted 805 million tonnes of greenhouse gases in 2019 (Figure 12) – roughly 54 million tonnes less than in the previous year. This figure equals a reduction of 35.7 per cent compared with 1990. In 2019, the energy sector again accounted for the largest share of German greenhouse gas emissions (32 per cent). Industry was the second-largest emitter, at 23 per cent, followed by transport (20 per cent) and the buildings sector (15 per cent). Agriculture accounted for eight per cent of the overall emissions in 2019, with waste management emitting one per cent. The land use, land use change and forestry sector improved its carbon footprint. It reduced overall emissions by 27 million tonnes of CO_2 equivalents in 2018.

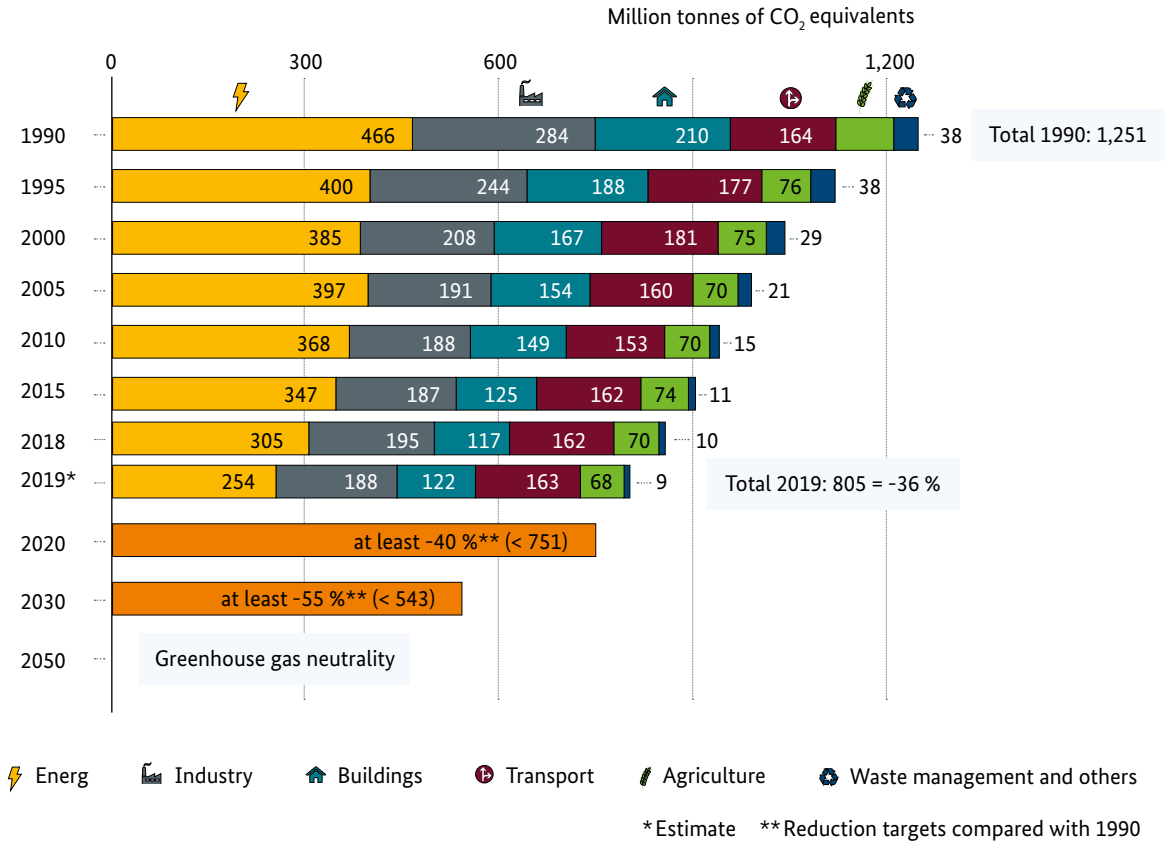
Figure 12: **2019 greenhouse gas emissions in Germany by sector**



In million tonnes of CO_2 equivalents
The values are based on forecasts.

Source: UBA (2020b)

Figure 13: **Greenhouse gas emission trends in Germany by sector (excluding LULUCF)**



Sources: UBA (2020a), UBA (2020b)

3.1 Emissions in Germany – past, present and future

According to initial estimates, greenhouse gas emissions in Germany decreased by roughly 35.7 per cent between 1990 and 2019 (1990 to 2018: -31.4 per cent). Having emitted 1,251 million tonnes of CO_2 equivalents in 1990, Germany had reduced its annual emissions to roughly 805 million tonnes of CO_2 equivalents by 2019 (Figure 13).

This decrease in emissions can be traced back to climate and energy policy efforts and measures undertaken by the Federal Government and the European Union. Macroeconomic and climate-related fluctuations also influence greenhouse gas emissions. In the early 1990s and during the financial and economic crisis in 2009, emissions came down due to macroeconomic factors and as a result of economic upheaval in the Federal States of the former East Germany. Weather-related fluctuations affect emission levels too, mostly because of a variable heating demand from year to year.

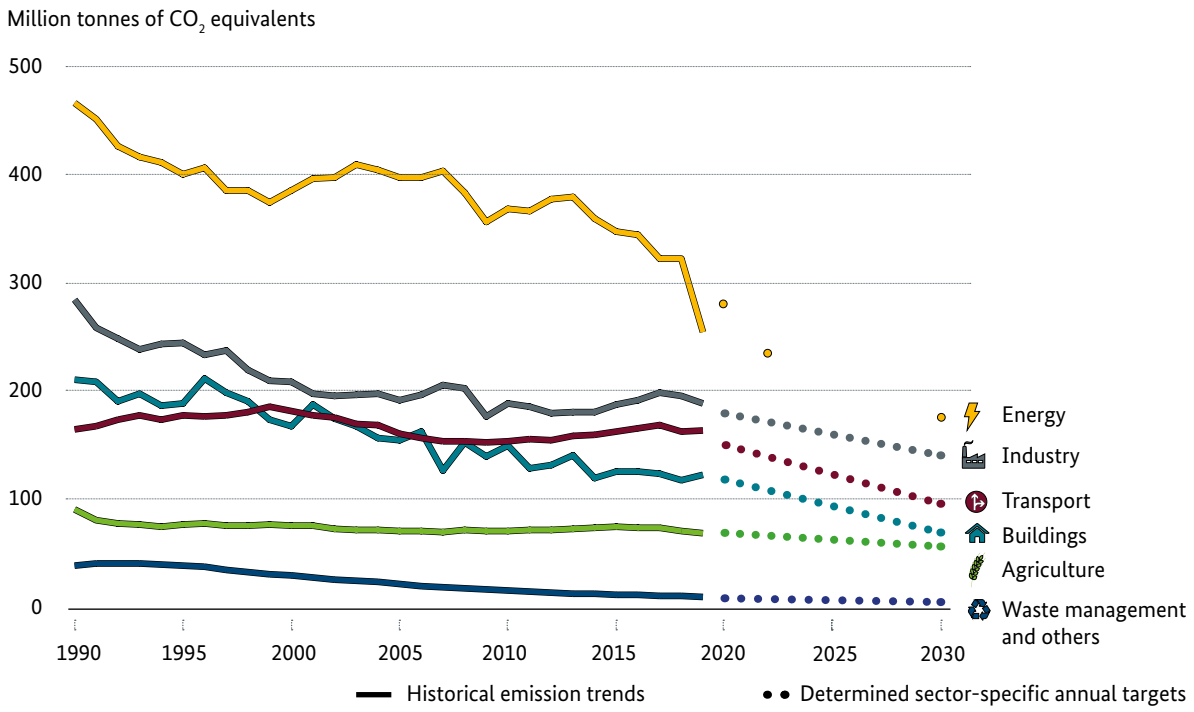
2019 saw a significant reduction in overall emission levels. This was due to increased emission allowance prices in the EU Emissions Trading System compared with previous years. Also, constant growth in the share of renewable energy and improvements in energy efficiency played a role here. International trade disputes adversely affected economic growth in 2019, further lowering greenhouse gas emissions. The slightly cooler weather and growth in population did in fact lead to an increased energy consumption and the associated emissions. Overall, however, the factors increasing consumption were weaker than the factors that caused a decline in consumption.

This brochure reports greenhouse gas emissions based on the source principle, the method generally used in international greenhouse gas reporting. According to this principle, emissions are attributed to the sector in which they first originate. For example, all emissions from public electricity and district heat generation are attributed to energy, even if the electricity or heat is used in transport or buildings.

With a successful 212 million tonnes of CO_2 equivalents since 1990, the energy sector has made the largest contribution to greenhouse gas reduction. Emissions in industry were reduced by a further 96 million tonnes of CO_2 equivalents, while emissions in the buildings sector decreased by 88 million tonnes. Reductions were also achieved in agriculture and waste management (22 and 29 million tonnes of CO_2 equivalents respectively). In transport, however, greenhouse gas emissions have stagnated since the early 1990s.

The individual sectors are required to reduce their emissions each year in line with the path to target achievement until 2030 (dotted lines in Figure 14). According to reports commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)[18] and the Federal Ministry for Economic Affairs and Energy (BMWi),[19] the measures implemented to date will not be sufficient to achieve the sector targets by that time. One exception is waste management, where climate targets will probably be met. The deviations from the target values vary by sector. While projections for energy, industry and buildings reveal only minor deviations from the targets if no additional measures are taken, agriculture and transport have greater gaps to bridge.

Figure 14: **Greenhouse gas emission trends and determined annual targets by sector**



Further information on greenhouse gas emission trends and the determined annual targets by sector can be found in the data appendix on page 66.

Sources: UBA (2020a), UBA (2020b), Federal Government (2019)

3.2 Energy

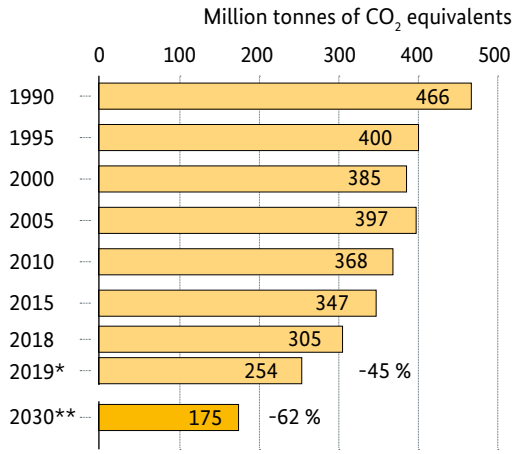
Emission trends

In 2019, the energy sector accounted for the largest share of emissions (32 per cent). This figure corresponds to 254 million tonnes of CO_2 equivalents (Figure 15). Emissions from the energy sector are largely caused by power plants burning fossil fuels to supply electricity and heat to the public (Figure 16). Emissions from refineries and transporting fossil fuels in pipelines, as well as "diffuse emissions", are also attributed to the energy sector. For example, they include mine gas released from decommissioned mines.

Initial estimates indicate that in 2019, energy-related greenhouse gas emissions decreased by a significant 17 per cent, compared with the previous year. There are several reasons for the decrease. One key cause was the increasing replacement of coal-fired power plants with renewable energy sources and gas in the energy mix. Besides low global market prices for gas, the successful reform of the EU Emissions Trading System, which resulted in higher CO_2 prices, also had an impact. The average price for a tonne of CO_2 in 2019 (24.65 euros) was almost twice that in 2018, leading to more expensive operations for coal-fired power plants than for gas-fired stations throughout the year. Moreover, a total capacity of 3.5 gigawatts of hard coal-fired power plants was decommissioned and transitioned to the grid reserve in 2019. The transition of lignite-fired power plant units to the security standby in October 2018 and 2019 led to further emission reductions. Power generation from wind and solar energy also reached record levels. By using renewable energy sources, the energy sector avoided emissions of an estimated 203 million tonnes of CO_2 equivalents in 2019. However, this was primarily due to the particularly windy and sunny weather with a simultaneous overall decline in demand, rather than to the construction of new plants.

The energy sector had already achieved comprehensive emission reductions in the past. Compared with 1990 as a baseline, the energy sector's greenhouse gas emissions had decreased by 45 per cent by 2019. From reunification until 1993, emissions in the former East Germany decreased at an above-average rate, as emission-intensive industrial facilities and lignite power plants were decommissioned because they did not meet environmental standards.

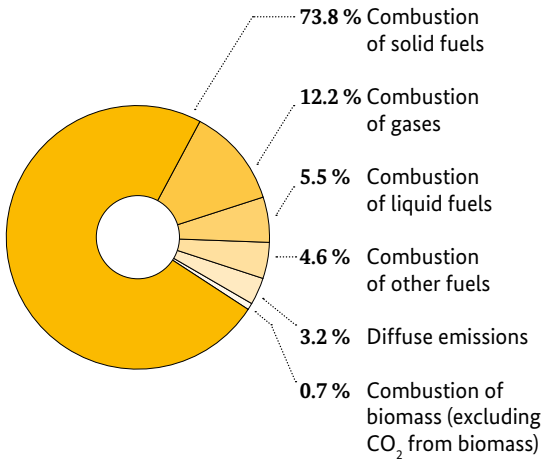
Figure 15: **Emission trends in the energy sector**



*Estimate **Reduction target compared with 1990

Sources: UBA (2020a), UBA (2020b)

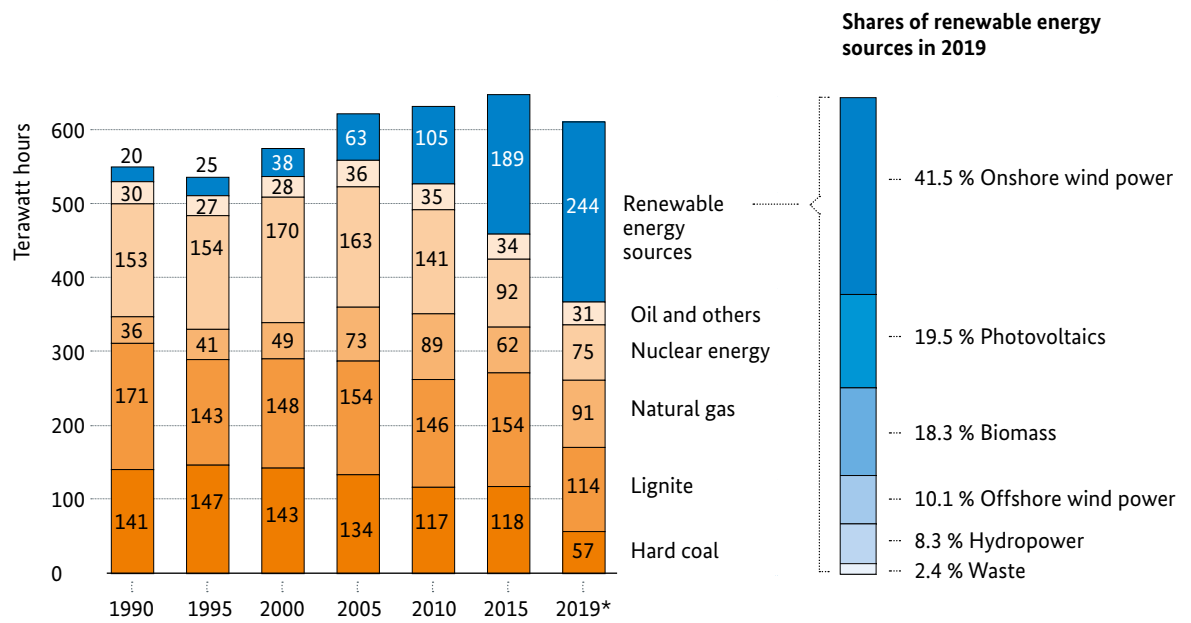
Figure 16: **Emission sources in the energy sector excluding CO_2 from biomass (2018)**



Source: UBA (2020a)

In recent years, an increasing number of coal-fired and nuclear power plants have had to reduce their outputs in summer, as the water levels in many rivers were too low and the water was not cold enough to cool the power plants. The low water levels also affected deliveries of hard coal to the power plants.[20] Since 2014, there have been considerable constraints to shipping traffic in three periods, which also affected the transport of coal to Southern German power plants.

Figure 17: **Gross electricity generation trends by energy source**



Source: BMWi (2020)

As a result, the electricity generation of the affected coal-fired power plants was lower and with it their emissions too.

Electricity generation from renewable energy sources has increased significantly since 1990 (Figure 17). In 2019, renewables accounted for 42.1 per cent of gross power consumption, according to the preliminary estimate by the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen). Wind turbines provided roughly half of the renewable electricity. Photovoltaics and biomass each contributed approximately 20 per cent to renewable power generation.

The nuclear phase-out was initiated in 2000 and finally adopted in 2011. Since then, nuclear power plants in Germany have been gradually disconnected from the grid, following a fixed schedule. As a result, the proportion of electricity generated from nuclear energy has been declining since the 2000s. Seven reactor units are currently still running in Germany. They are slated to be decommissioned gradually by the end of 2022.

The use of coal in the energy sector, which is particularly harmful to the environment, decreased significantly in 2019. Compared to the previous year, electricity generation from hard coal-fired plants decreased by 31 per cent, while power production from lignite-fired plants decreased by 22 per cent. At the same time, gas-fired power generation, which causes relatively lower greenhouse gas emissions, increased by ten per cent.

Gas, another fossil fuel, has played a growing role in power generation in recent years. Natural gas is being used as a bridge technology during the energy system's transition to renewable energy sources. Compared with coal-fired and nuclear plants, gas-fired power plants are more flexible in operation, so they are well suited to compensate for natural fluctuations in renewable energy generation. This is a necessary step to take until renewables provide enough electricity and sufficient flexibility options. Compared with the other fossil fuels – lignite, hard coal and oil – generating power from natural gas causes lower greenhouse gas emissions.

Areas of action and measures

To achieve its target of greenhouse neutrality, the Federal Government aims to fully decarbonise Germany's energy supply by 2050. By 2030, emissions are to drop to 175 million tonnes of CO_2 equivalents. For the energy sector to meet the Federal Government's reduction targets, effective national measures must be taken to supplement the EU Emissions Trading System. Action is required in particular to phase out coal power, drive the expansion of renewables in electricity, heat and transport and boost energy efficiency.

By increasing the efficiency of energy use, the energy requirements of buildings, transport and industrial plants are expected to fall steadily. Based on current knowledge, an increase in sector coupling will boost electrification in the transport, industry and buildings sectors, which in turn will foreseeably increase the demand for power. In particular after 2030, the increasing electrification of transport and building heating are expected to substantially increase demand, in spite of simultaneous efforts to increase energy efficiency.

In its Coal Phase-out Act (Kohleausstiegsgesetz), the Federal Government aims to pave the way for phasing out coal-based power generation by 2038 at the latest (Figure 18). The climate targets can only be reached if the use of coal for electricity generation stops as soon as possible. The phase-out is to be implemented gradually and in a socially acceptable manner. To this end, the Federal Cabinet passed the draft Structural Development Act (Strukturstärkungsgesetz) for coal-mining regions in August 2019. The installed generation capacity from coal-fired power plants on the market is initially to be reduced to 30 gigawatts by 2022 and to 17 gigawatts by 2030.

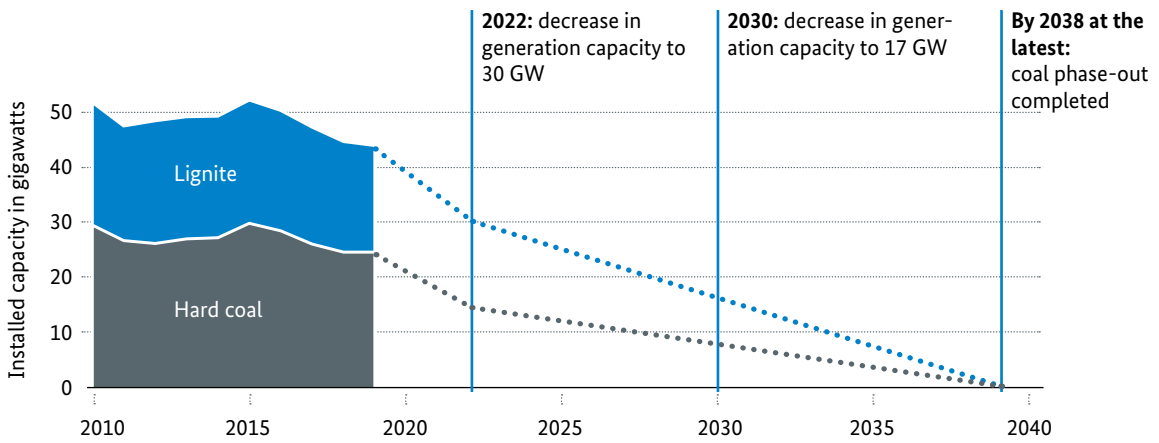
79

million tonnes of CO_2 equivalents

Within the next ten years, emissions in the energy sector are to decrease by 79 million tonnes of CO_2 equivalents (31 per cent).

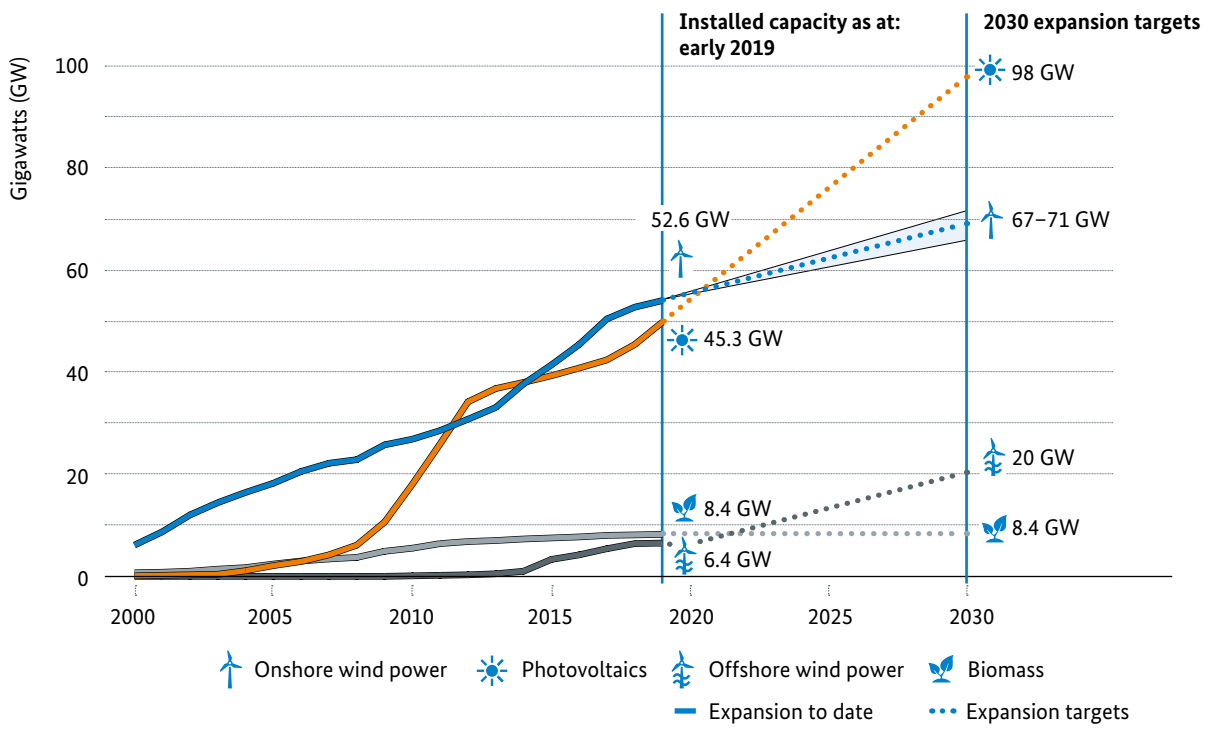
In future, renewables will be the main source of energy. According to the Federal Government's target, 65 per cent of energy consumed will be generated from renewable sources by 2030. Wind and solar power in particular are to be expanded extensively, in line with the Federal Government's targets (Figure 19). By 2030, solar generation capacity is to be more than doubled from the current level of roughly 45 gigawatts to a target of 98 gigawatts. According to Federal Government plans, onshore wind energy generation capacity is to rise from 53 gigawatts in 2019 to between 67 and 71 gigawatts by 2030. The use of wind energy in the Baltic and North Sea will be expanded

Figure 18: **Planned coal phase-out path**



Sources: BMWi (2020), Federal Government (2020b)

Figure 19: **Past and planned expansion of renewable energy in Germany**



Sources: BMWi (2020), BWE (2019), Federal Government (2019b)

further and is to be increased from the current six gigawatts to 20 gigawatts by 2030. Biomass will play a limited role in energy provision and will mainly be based on generating energy from waste and liquid manure, fermentation and other residues. The present generation capacity is sufficient to harness the energy of these substances, and will therefore remain constant under the Federal Government's plans.

Expanding onshore wind energy has been increasingly challenging in recent years. In the record year of 2017, 2,489 wind turbines were connected to the grid, whereas 2019 saw the commissioning of only 287 turbines. The sharp decline in wind energy expansion is due to strict regulations on minimum distances to residential areas in some Federal States, insufficient land-use planning, delays to many projects due to numerous objections in the planning phase, and organised protest by wind power opponents.

> ***"One hundred per cent renewable energy in Germany is technically possible, makes economic sense and is ecologically necessary."*** *Dr. Eckart von Hirschhausen, doctor and cabaret artist*

Thousands of jobs have already been lost due to the negative trends. According to a report, a further 17,000 jobs in the wind industry are in danger. This is roughly equivalent to the current workforce of the coal industry, which employs about 20,000 people.[21]

3.3 Industry

Emission trends

In 2018, the industrial sector accounted for 23 per cent of greenhouse gas emissions. This figure corresponds to 195 million tonnes of CO_2 equivalents (Figure 20), making industry the second-largest greenhouse gas emitter in Germany. According to initial estimates, industrial emissions in 2019 decreased by four per cent to 188 million tonnes of CO_2 equivalents. Overall, emissions in the sector decreased by 34 per cent between 1990 and 2019. Much of this reduction was achieved in the 1990s due to the economic upheaval in the Federal States of the former East Germany, among other factors. Industrial greenhouse gas emissions have only declined slightly since 2001 (197 million tonnes of CO_2 equivalents), except for macroeconomic fluctuations.

Industrial greenhouse gas emissions arise primarily in the energy-intensive sectors: steel, chemicals, non-ferrous metals, cement, lime, glass and paper, as well as in power generation for self-consumption in industrial facilities. However, these emissions have different causes. Roughly two thirds are caused by direct power provision in the industry (furnaces), while one third of industrial emissions is process-related (Figure 21). Process-related emissions are incurred in production processes, in particular during the production of raw materials like pig iron, cement and basic chemicals.

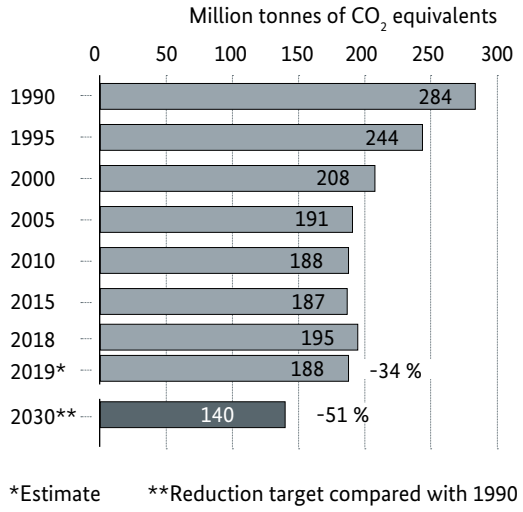
Besides direct greenhouse gas emissions, industry also causes indirect emissions through the procurement of third-party electricity and district heating. According to the source principle, these emissions are attributed to the energy sector. An improvement in industrial energy efficiency therefore also has a positive effect on the emission balance in the energy sector. The energy produced and consumed internally by the industrial sector results in the final energy consumption broken down in Figure 22.

48

million tonnes of CO_2 equivalents

Within the next ten years, emissions in the industrial sector are to decrease by 48 million tonnes of CO_2 equivalents (25 per cent).

Figure 20: **Emission trends in the industrial sector**



*Estimate **Reduction target compared with 1990

Sources: UBA (2020a), UBA (2020b)

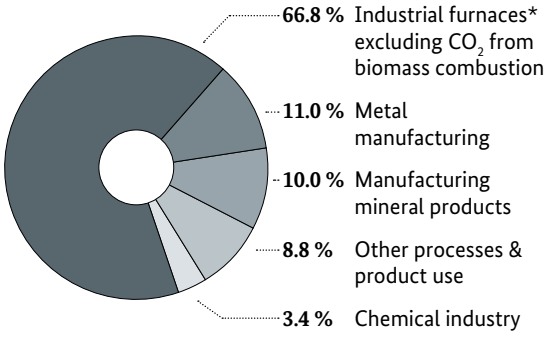
Areas of action and measures

In recent years, the industrial sector has made advances in process optimisation and improving energy efficiency. However, as the resulting energy and greenhouse gas savings per unit produced is offset by an increase in production volumes, the industrial sector has only achieved a minor greenhouse gas reduction of one per cent in the last 15 years (Figure 20).

By 2030, industrial greenhouse gas emissions are to decrease gradually to 140 million tonnes of CO_2 equivalents. This value corresponds to an overall reduction of 25 per cent compared with 2019. To achieve this target, the Federal Government has combined comprehensive sector-specific measures in the Climate Action Programme 2030, which are designed to further reduce industrial emissions and reach the targets for 2030, supplementing the EU Emissions Trading System and other existing measures.

Industrial manufacturing is to become greenhouse gas-neutral. Besides the challenge of avoiding process-related emissions, energy must also be provided without causing greenhouse gas emissions. Key areas for action in this field include the reduction of energy consumption through a further energy efficiency boost, and the increase of renewable energy and waste heat utilisation.

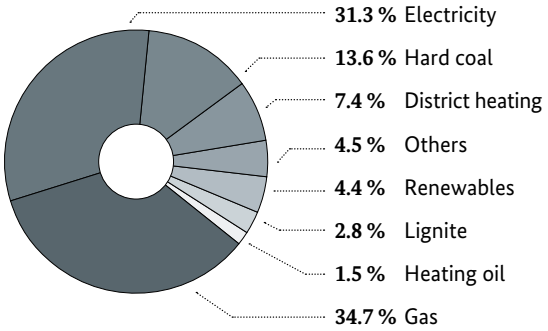
Figure 21: **Emission sources in industry (2018)**



*Combustion processes, for example from firing rotary kilns

Source: UBA (2020a)

Figure 22: **Final energy consumption by energy source in industry (2018)**



Source: BMWi (2020)

Investments in existing high-efficiency technologies and renewable energy systems are promoted through the central support programme "Energy efficiency and process heat from renewable energy sources in the economy". Besides individual investments, the programme also supports systematic optimisations of entire production locations. Other schemes promote the use of new construction technologies and materials, for example, as well as projects and measures for resource efficiency and substitution.

Process-related emissions can be reduced by optimising the use of material and resources. For instance, recycling more can significantly reduce the need for primary materials. However, fully eliminating process-related emissions will require a substantial transformation of entire production processes. These are particularly in need of transformation for products like steel, cement, lime and non-ferrous metals, as well as some basic chemicals.

Comprehensive support programmes are planned for the research, development and market roll-out of climate-friendly technologies. For example, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) promotes large-scale technical projects to avoid process emissions in energy-intensive industries through its "Decarbonisation in industry" support programme. Projects funded under this scheme aim to extensively and sustainably reduce process-related greenhouse gas emissions that are impossible to avoid, or can only be avoided with great difficulty, using the current state of the art.

The Competence Centre on Climate Change Mitigation in Energy-intensive Industries (KEI), founded in Cottbus in November 2019, was commissioned to implement this support programme. The KEI will also advise energy-intensive industries on matters related to decarbonisation (see Section 4.3). Besides the "Decarbonisation in industry" support programme, the Climate Action Programme 2030 provides for further research programmes, for example on CO_2 used as a material. The planned national hydrogen strategy, the Power-to-X (PtX) action programme and the Climate Action in Industry innovation pact will provide additional stimuli to transform the industrial sector.

Restructuring industry is an urgent matter at a European level too. The European Green Deal declares climate action in this sector a priority for the European Commission. A new EU industrial strategy is to be passed in March 2020. Starting in mid-2020, the EU Innovation Funds will make significant funding available to decarbonise industry.

i

Process-related emissions as a challenge for climate action in the industrial sector

Roughly one third of industrial emissions is not related to energy, but caused by manufacturing processes, especially of raw materials like pig iron, cement and basic chemicals.

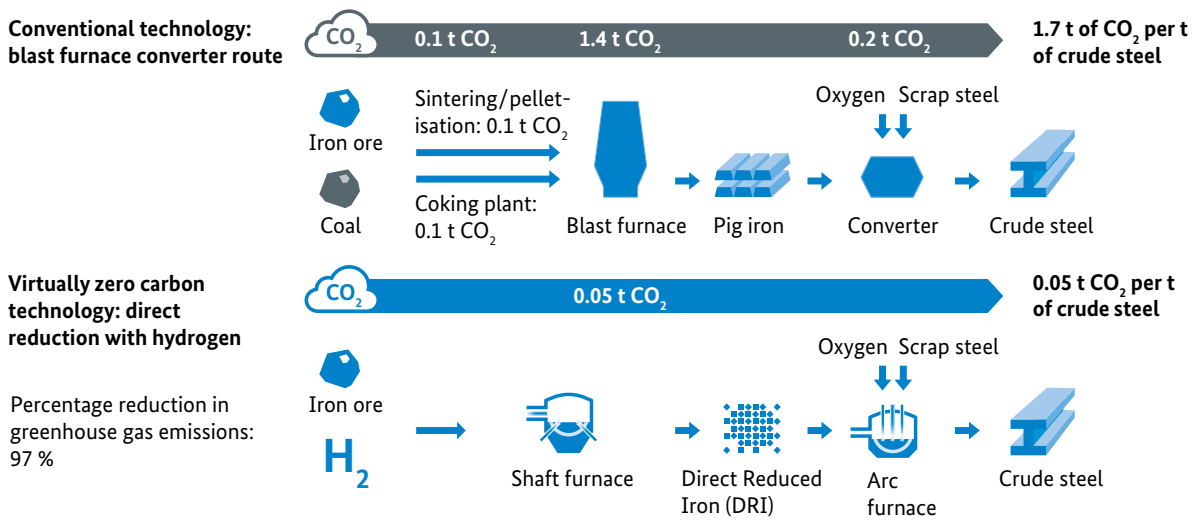
Cement is a raw material and a key component of concrete and mortar as a binding agent. In cement production, process emissions result from the deacidification of limestone during clinker burning, a sub-step in cement production. As part of this process, CO_2 is released from the limestone, which contains calcium carbonate ($CaCO_3$).

In steel production, process emissions are largely caused by coking coal, used as a reducing agent in blast furnaces. In this process, oxygen is seperated from the iron ore (Fe_2O_3 and Fe_3O_4) in a chemical reaction with carbon (C), removing the iron content from the ore. Besides the pig iron (Fe), which is used to manufacture steel in later stages of the production process, this step produces blast furnace gas, which largely consists of CO_2. The processes for manufacturing basic chemicals are highly energy-intensive and also release significant quantities of CO_2 due to the processes involved.

Steam cracking, a thermal process that converts long-chain hydrocarbons to short-chain hydrocarbons, is a key process in basic chemistry. This process is used to make plastic from crude oil with some intermediate steps. Steam reformation is another key process. It is used to generate hydrogen from natural gas and steam to produce ammonia.

Besides the conventional and emission-intensive production processes currently in use, all industries have developed their specific solutions for novel, low-emission production processes. These make extensive use of renewable electricity and hydrogen, avoiding process-related emissions by design. Figure 23 compares a low-emission steel manufacturing method with the conventional production process as an example. To promote innovative technologies is a key priority for climate policy in the industrial sector.

Figure 23: **Process emissions in the industrial sector – decarbonisation option for steel manufacturing**



Source: Agora Energiewende and Wuppertal Institut (2019)

3.4 Transport

Emission trends

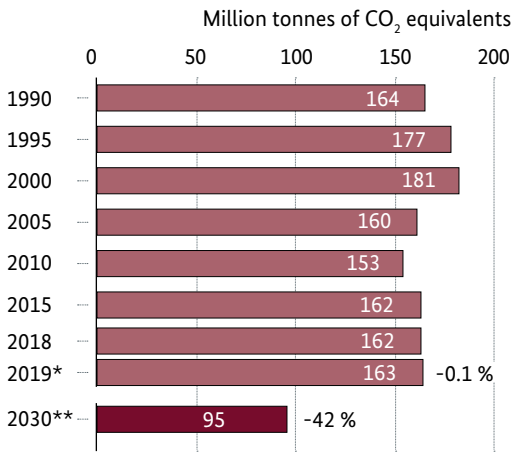
In 2019, the transport sector emitted 163 million tonnes of greenhouse gases. Following energy and industry, transport is the third-largest greenhouse gas emitter in Germany. Between 1990 and 2018, transport-related emissions only decreased by one per cent to 162 million tonnes of CO_2 equivalents (Figure 24). According to initial estimates, emissions in 2019 were slightly higher than the previous year (plus 0.7 per cent), totalling 163.5 million tonnes of CO_2 equivalents. Transport therefore accounted for 20 per cent of overall German emissions in 2019. Carbon dioxide makes up 99 per cent of greenhouse gas emissions in this sector.[22] The main reasons for the continuing high CO_2 emissions in transport are the predominance of fossil fuels, the increasing mileage travelled, heavier passenger vehicles and the increasing number of cars and flights for passenger and freight transport.

Motorised road transport accounts for 94 per cent of transport-related greenhouse gas emissions. Roughly 59 per cent of this share is emitted by passenger cars and 35 per cent by heavy goods vehicles (HGVs) and other commercial vehicles. The other four per cent is caused by national aviation, shipping and rail transport (Figure 25). International aviation and shipping are not included in national transport-related greenhouse gas emissions. Emissions from electricity consumption in transport are also excluded. In accordance with the source principle, these are attributed to the energy sector.

Passenger transport is constantly increasing. Between 1990 and 2017, traffic rose by roughly 64 per cent to 1,195 billion passenger kilometres. Of these, roughly 75 per cent were completed in passenger cars, taxis or rental cars, whereas 19 per cent occurred in public transport. The latter increased by five per cent in the past 15 years. The shares of pedestrian and cycling trips remained unchanged at three per cent each in the same period (Figure 27).[23]

The transition to low-emission engines in road transport is slowly gathering speed. Carbon dioxide emissions from passenger cars depend primarily on the engine type and the shape and weight of the vehicle. Since 1995, CO_2 emissions per kilometre of the

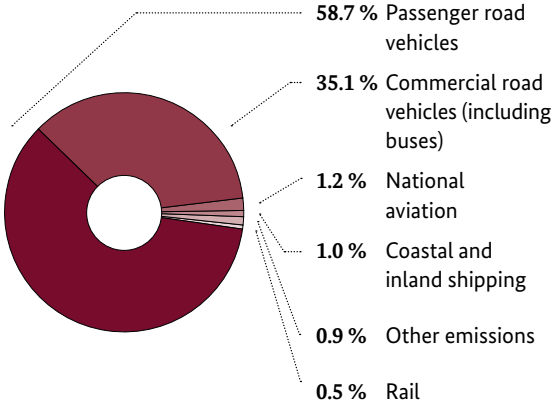
Figure 24: **Emission trends in the transport sector**



*Estimate ** Reduction target compared with 1990

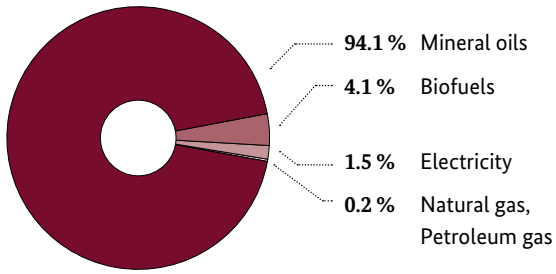
Sources: UBA (2020a), UBA (2020b)

Figure 25: **Emission sources in the transport sector (excluding CO_2 from biofuels) (2018)**



Source: UBA (2020a)

Figure 26: **Final energy consumption by energy source in transport (2018)**



Source: BMWi (2020)

68

million tonnes of CO_2 equivalents

Within the next ten years, emissions in the transport sector are to decrease by 68 million tonnes of CO_2 equivalents (42 per cent).

passenger car fleet in Germany have decreased by 14.7 per cent.[24] However, greater reductions in the specific CO_2 emissions would be possible if the efficiency improvements were not largely offset by the trend to buy larger, heavier and more powerful vehicles. Among EU countries, Germany accounts for the second-highest average CO_2 emissions for new cars.[25] Passenger transport is still dominated by fossil fuels. Petrol and diesel engines remain by far the most common powertrains, at 91 per cent of new cars registered, while alternative electric, hybrid, liquefied and natural gas engines make up the remaining nine per cent (Figure 28). Demand for alternative drives, such as electric motors, is rising. To ensure that electric vehicles remain greenhouse gas-neutral, they must be operated entirely on electricity from renewable energy sources. In the current electricity mix, battery electric vehicles cause 27 per cent less emissions than petrol passenger cars and are more climate-friendly than any other engine types over their service life.[26]

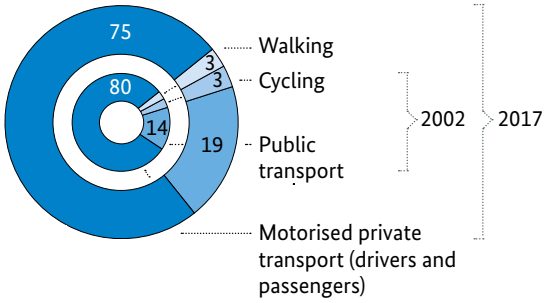
Freight transport has increased in recent years. In domestic freight transport, the transport volume rose by 74 per cent between 1991 and 2017 to 696 billion tonne-kilometres (Figure 29). In 2017, 71 per cent of goods were transported by road, with rail and inland shipping playing a smaller role.[27] Air freight has grown fastest in recent years, while inland shipping has decreased.[28]

Areas of action and measures

By 2030, greenhouse gas emissions in transport are to decrease by 42 per cent compared with 1990. To achieve the permitted annual emission volume of 95 million tonnes of CO_2 equivalents in 2030, a fundamental overhaul of the transport sector is required. Political priorities include increasing the energy efficiency of all forms of transport, transitioning to emission-free engines and fuels, shifting to public or shared means of transportation (rail, bus, car-sharing and ride-sharing) as well as walking and cycling, and ultimately using improvements in logistics to avoid excessive transportation.

At a European level, directives set targets for the share of renewable energy sources in the fuel mix and the CO_2-intensity of the fuels, among other things. Car manufacturers are subject to fleet limits for the average greenhouse gas emissions of their new vehicles. In 2018, the average emission figure for new passenger cars registered in Germany was 130 grams per kilometre,[29] and 120 grams of CO_2 per kilometre in the EU.[30] By 2021, passenger car manufacturers are obliged to reduce their average emissions to 95 grams of CO_2

Figure 27: **Chosen modes of transport compared in passenger transport, 2002 and 2017**



Shares as percentage values of person-kilometres

Source: BMVI (2019)

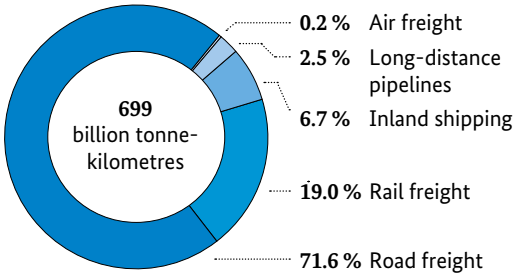
Figure 28: **Shares of passenger car powertrains in Germany (2019)**

	Passenger car stock	New registrations
Total	**47.7 million**	**3.6 million**
Petrol	66 %	59 %
Diesel	32 %	32 %
Alternative drives*	2 %	9 %

*Liquid petroleum gas, natural gas, electric, hybrid

Sources: KBA (2020a), KBA (2020b)

Figure 29: **Shares of the transport modes in freight traffic in Germany (2017)**



Source: BMVI (2020)

per kilometre. In the period from 2021 to 2030, the CO_2 emissions of new cars must decrease by a further 37.5 per cent. Light commercial vehicles will be subject to a limit of 147 grams of CO_2 per kilometre from 2020 on. Between 2021 and 2030, their emissions are to decrease by 31 per cent compared with 2020. From 2025 on, manufacturers of heavy goods vehicles (HGVs) will be subject to binding targets for the first time. The average CO_2 emissions of new heavy goods vehicles must decrease by 15 per cent by 2025 and 30 per cent by 2030 compared to the reference period (July 2019 to June 2020). Fleet limits can be achieved both by increasing efficiency in vehicles and by increasing the share of electric vehicles. Manufacturers will be liable for penalties if these targets are not met. To facilitate a realistic emissions measurement in new passenger cars and light commercial vehicles, the United Nations "Worldwide Harmonized Light Vehicles Test Procedure" (WLTP) has been applicable in the European Union since 2017.

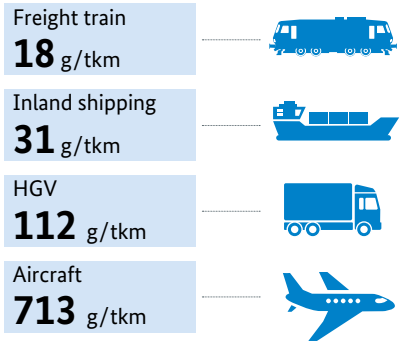
The Climate Action Programme 2030 introduces CO_2 pricing for the transport sector. The National Emissions Trading Scheme (nETS) covers emissions from the combustion of fossil fuels, including petrol, diesel and natural gas. The CO_2 price will initially make fossil fuels three cents more expensive per litre from 2021 on and raise the price annually thereafter. The additional expense will be hardly perceptible for end consumers in the early phases of emissions trading. However, the gradual increase in CO_2 prices provides guidance for future purchase decisions and will lead to a relative price increase for means of transport that harm the climate in the long term.

The Federal Government promotes climate-friendly alternatives in transport. To shift to more climate-friendly options, local public transport, cycling, railways and inland shipping are to be enhanced.

To travel long distances, trains and buses are the most climate-friendly means of transport. The Federal Ministry of Transport and Digital Infrastructure (BMVI) has set itself the goal of doubling the number of train passengers within the next ten years.[31] By 2030, the Federal Government and Deutsche Bahn will invest 86 billion euros to modernise and expand the network of railways. A capital increase at Deutsche Bahn, totalling one billion euros annually between 2020 and 2030, will make further funds available for investments in the rail system. To permit greater utilisation of rail transport, digital control and safety technology will be introduced and more signal boxes will be digitalised. To make rail travel financially more attractive, the value added tax on rail tickets is to be reduced in accordance with the Climate Action Programme 2030. At the same time, charges levied on air travel will increase.

In local transport, the attractiveness and the eco-friendliness of local public transport are to be improved. The Climate Action Programme 2030 includes plans to provide one billion euros in federal funding to expand local public transport from 2021 on. Municipalities can use the funds to expand and modernise

Figure 30: **Greenhouse gas emissions in CO_2 equivalents by transport modes in freight transport (2018)**



In grams per tonne-kilometre (g/tkm)

Source: UBA (2020c)

the local rail transport network, or to purchase electric buses. The Federal Government intends to increase federal funding for upgrading local public transport to two billion euros annually from 2025 on. In addition, support for buses with electric and hydrogen-based engines and biogas-powered buses will continue.[32]

Walking and cycling have the lowest environmental impact. The Federal Government plans to support cycling with the National Cycling Plan 2020 and the measures from the Climate Action Programme 2030. Cycle paths and fast cycle routes are being expanded, and the road infrastructure for cyclists is being improved. Additionally, dedicated programmes for urban and rural environments are planned to improve the attractiveness of cycling, for example with secure and modern bike racks and through the expansion of the infrastructure for cargo bikes.

To mitigate emissions from motorised individual transport, the Federal Government promotes the use of electric vehicles and alternative fuels. In the field of electric mobility, the charging infrastructure in particular will be expanded. In November 2019, 21,100 public charging stations were available in Germany for users of electric vehicles.[33] In line with the Federal Government targets, one million charging stations are to be installed by 2030, and between seven and ten million electric vehicles are to be registered.

Rail and inland shipping have the best carbon footprint for freight transport. With average emissions of 19 grams of CO_2 equivalents per tonne-kilometre, rail is the most climate-friendly means of transporting freight, followed by inland shipping with 32 grams of CO_2 equivalents per tonne-kilometre (Figure 30).[34] Accordingly, the Federal Government is promoting freight transport by rail and inland shipping. Besides expanding the rail network, the Government is also supporting combined transport, which refers to integrated chains comprising various means of transport.

According to the Federal Ministry of Transport and Digital Infrastructure's Inland Shipping Master Plan, the aim of modernising and digitalising the waterway infrastructure is to increase the percentage of inland shipping. The Climate Action Programme 2030 also includes plans to expand the shore-side power infrastructure in ports to avoid the use of ship engines for power generation in ports, which is harmful to the climate and environment.

> ***"In contrast to energy, we have not achieved any successes in mobility over the past 15 years. On the contrary: cars have become bigger, fuel consumption is rising, traffic is increasing, and roads and airports are full."*** *Dr. Dirk Messner, UBA President*

More low-carbon heavy goods vehicles will be brought to market to reduce the carbon footprint of road freight transport. By 2030, roughly one third of the road-based heavy goods transport volume is to be covered by electric engines or electricity-based fuels. The Federal Government will promote the procurement of heavy goods vehicles with alternative, climate-friendly powertrains, including hydrogen-based technologies and the expansion of a demand-driven refuelling and charging infrastructure. The truck toll will be split into categories based on the vehicles' CO_2 emissions, to promote climate-friendly powertrains as part of the amendment of the Eurovignette directive from 2023 on.

Ultimately, the potential of digitalisation is to be used to automate and network mobility in the whole sector, for example to make local public transport more attractive.

3.5 Buildings

Emission trends

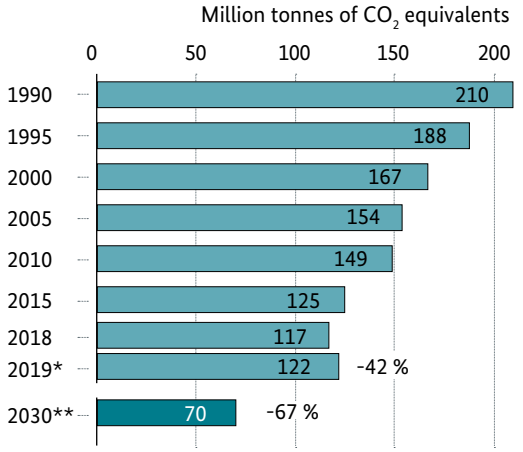
In 2018, buildings accounted for 14 per cent of overall emissions in Germany. According to initial estimates by the Federal Environment Agency, emissions in the sector rose by four per cent to 122 million tonnes of CO_2 equivalents from 2018 to 2019. This figure corresponds to a reduction by 42 per cent compared with the baseline year, 1990 (Figure 31). However, it has to decrease by a further 52 tonnes of CO_2 equivalents to reach the 2030 target of a maximum of 70 tonnes. Emissions in buildings are largely caused by burning fossil fuels (Figure 32) to provide space heating and hot water (Figure 33).

The buildings sector incorporates emissions from private homes and commerce, trade and services. Emissions resulting from direct energy provision in buildings are attributed to this sector. In contrast, emissions generated through the supply with power and heat by public service companies (like district heating, for example) are attributed to energy. If these indirect emissions were attributed to the emissions caused by the buildings sector, it would account for roughly 30 per cent of overall emissions in Germany.[35]

Greenhouse gas emissions in the buildings sector have decreased by roughly three per cent annually since 2010. The emission of greenhouse gases is highly dependent on the weather conditions. Cold winters increase emissions due to the rising demand for heating, which accounts for the lion's share of energy consumption in buildings. Hot summers increase the energy demand for cooling, causing greenhouse gas emissions to rise too. However, to date, unusually hot summers have caused a significantly weaker rise in emissions than cold winters, as in Germany few buildings are currently equipped with air conditioning systems.

There are over 21.7 million buildings in Germany. Out of these, about 19 million are residential buildings, of which about 12.5 million were built before the first Thermal Insulation Ordinance of 1979. Around 60 per cent of energy consumption in the buildings sector is used for heating. Another 24 per cent of consumption is divided into different heat and cold supply. While households primarily require hot water and process heat (for washing machines and dishwashers, for

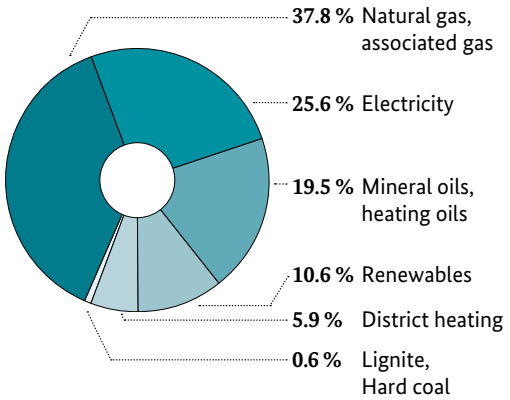
Figure 31: **Emission trends in the buildings sector**



*Estimate **Reduction target compared with 1990

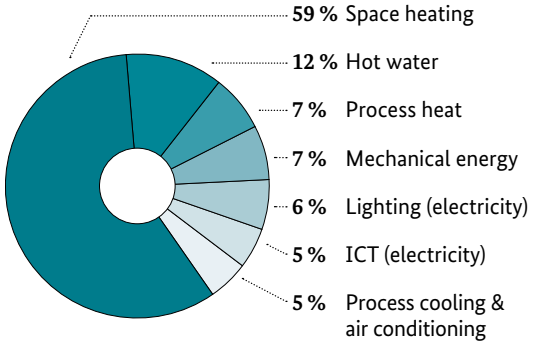
Sources: UBA (2020a), UBA (2020b)

Figure 32: **Final energy consumption by energy source in the buildings sector (2018)**



Source: BMWi (2020)

Figure 33: **Final energy consumption by applications in the buildings sector (2018)**



Source: BMWi (2020)

52

million tonnes of CO_2 equivalents

Within the next ten years, emissions in the buildings sector are to decrease by 52 million tonnes of CO_2 equivalents (42 per cent).

example), process cooling is an important factor for commerce, trade and services (Figure 33).

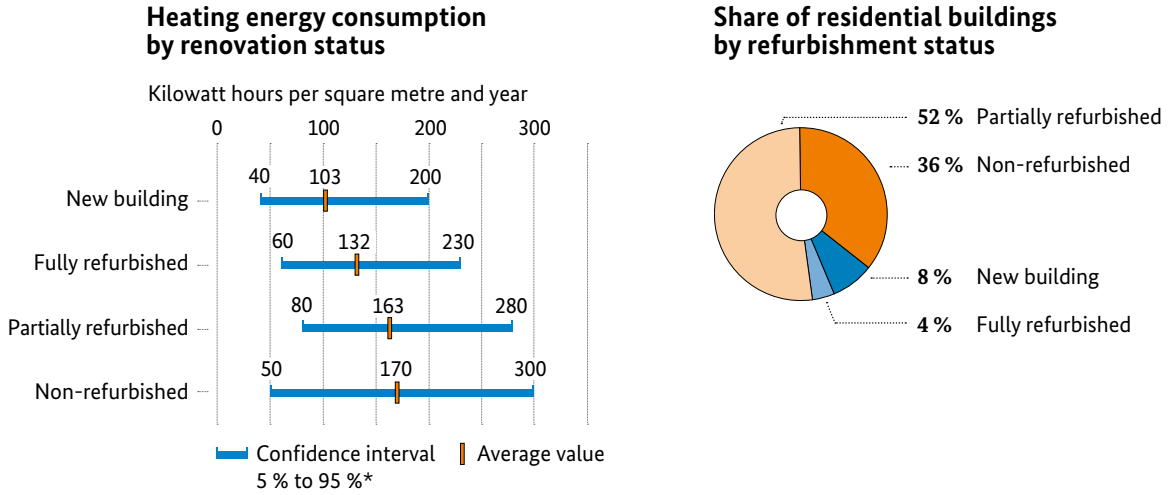
Areas of action and measures

Energy refurbishments can significantly reduce a building's heating energy consumption. New and fully refurbished buildings have a significantly lower energy consumption than unrefurbished or partially refurbished buildings (Figure 34). Refurbishment measures include insulation work on roofs, walls and windows and integration of electric heat pumps and renewable energy sources, like solar thermal systems and geothermal energy in heating systems.

In spite of every effort, the heating transition is still progressing slowly. The main reason for this is the lack of incentive structures for fundamental refurbishment measures. At just roughly one per cent per year, the refurbishment rate remains under the annual target of 1.5 per cent, which must be reached to meet the climate targets.[36]

In 2019, the Federal Government took a major step towards reaching its climate targets in the buildings sector, adopting the Climate Package. The Climate Action Programme 2030 unveiled a package of new measures. The CO_2 price in the planned National Emissions Trading Scheme also applies to the buildings sector, creating incentives for efficiency measures and a shift to lower emission heating systems. The funding of measures for the buildings sector will be pooled, simplified and significantly increased under the "Federal Funding for Efficient Buildings" programme. Energy refurbishments are also eligible for tax incentives. In future, energy standards will be developed and energy consulting services will be expanded. The Federal Government also plans to set a better example in future through its own buildings.

Figure 34: **Residential buildings and their heating energy consumption by renovation status**



*The confidence intervals map 90 % of all residential buildings in the respective category.

Source: co2online (2020)

3.6 Agriculture

Emission trends

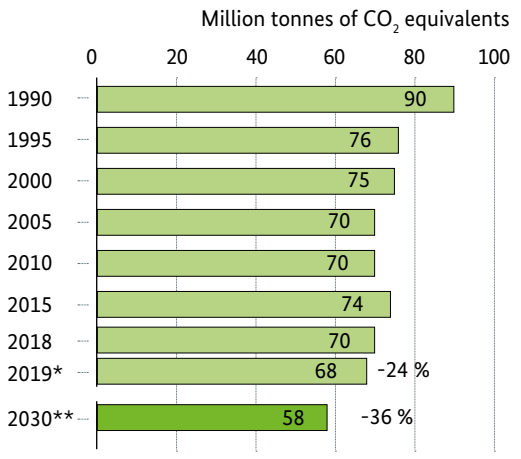
In 2018, the agricultural sector accounted for eight per cent of overall German emissions, at 70 million tonnes of CO_2 equivalents. In 2019, emissions decreased by two per cent to 68 million tonnes of CO_2 equivalents. This corresponds to a decrease of 24 per cent between 1990 and 2019 (Figure 35). The reduction of emissions is primarily due to the decrease in animal stocks, which occurred in the Federal States of the former East Germany immediately after German reunification. Set-asides of arable land, improved fertiliser management and the environmental requirements of the EU's Common Agricultural Policy (CAP) also contributed to some extent. The decline of greenhouse gas emissions in agriculture has been slower since the 2000s.

Emissions from land use and livestock farming account for the largest share of agricultural greenhouse gas emissions (Figure 36). Carbon dioxide emissions play a subordinate role. The greenhouse gases methane and nitrous oxide are particularly relevant for emissions in agriculture. In 2018, roughly 60 per cent of all methane and 80 per cent of the nitrous oxide emissions in Germany were generated by this sector.

Methane is primarily emitted in livestock farming by the digestive processes of ruminants and during the storage and distribution of livestock manure, for example as liquid manure, slurry and manure. Methane emissions in livestock farming are virtually entirely caused by cattle, and to a negligible extent by sheep. Cattle excrement also accounts for the largest share of methane from farm manure, with minimal emissions from pigs and other farm animals. As a greenhouse gas, methane is roughly 25 times as harmful to the climate as CO_2. Nitrous oxide emissions in agriculture derive chiefly from farming organic soils and using mineral-based fertilisers and livestock manure. Nitrous oxide is roughly 300 times as harmful to the climate as CO_2.

Carbon dioxide emissions in this sector are primarily caused by the fuel used in agricultural machinery and vehicles, and to a minor extent through the use of urea-based fertilisers, soil liming and the use of other carbon-containing fertilisers.

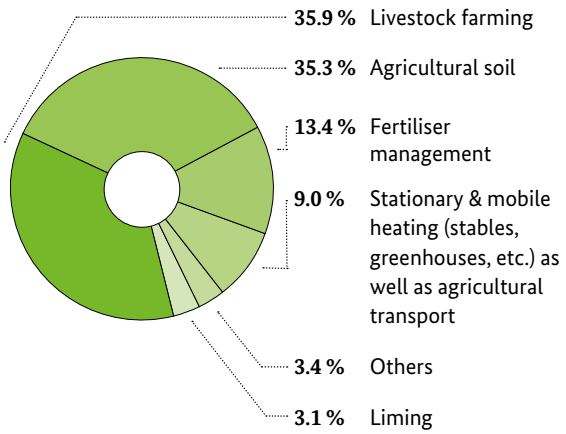
Figure 35: **Emission trends in the agriculture sector**



*Estimate ** Reduction target compared with 1990

Sources: UBA (2020a), UBA (2020b)

Figure 36: **Emission sources in the agriculture sector without CO_2 from biomass (2018)**



Source: UBA (2020a)

Areas of action and measures

Agriculture is both a greenhouse gas emitter and a victim of climate change impacts. The frequency of extreme weather events and the temperature increase strongly influence the harvest. The dry conditions in recent years have caused crop failures in many parts of

Germany. The Federal and State Governments provided a total of 340 million euros in aid to support farmers affected by the drought in 2018. Besides adapting farming to climate change, the Federal Government aims to harness the sector's potential for climate action.

By 2030, agricultural greenhouse gas emissions are to decrease by 36 per cent compared with 1990. Emissions from mobile and stationary combustion in agricultural enterprises and from agricultural vehicles and buildings are also attributed to this sector. In 2030, annual greenhouse gas emissions must be below the permitted annual limit value of 58 million tonnes of CO_2 equivalents.

Reducing nitrogen surpluses by using less nitrogen-containing fertiliser is one measure to reduce the greenhouse gas emissions in agriculture. In 2017, the amended Fertilisation Regulation introduced stricter requirements to ensure sustainable and efficient use of nutrients in farm operations. The requirements are also extremely important for water protection, as intensive fertilisation increases the risk of nitrate leaching into the ground water. In June 2018, the European Court of Justice ruled against Germany for failing to adequately implement the EU Nitrates Directive. The Federal Government therefore submitted proposed changes to the 2017 Fertilisation Regulation to the European Commission to implement the judgement.

The Federal Government aims to promote organic farming. To this end, it aims to promote particularly environmentally friendly processes in its legislation, and to optimise its legal and financial support. Organically farmed land is to increase from 8.2 per cent of all agricultural land at present to 20 per cent in 2030. The Federal Government provides 36 million euros annually to support organic farming. Added to this are funds from the "Joint Task for the Improvement of Agricultural Structures and Coastal Protection", which do not, however, benefit organic farming exclusively.

The Common Agricultural Policy will remain one of the largest items in the EU budget in future. With its support schemes, it has a significant influence on the intensity of farming and the overall condition of the environment. Between 2014 and 2020, Germany received a total of roughly 6.2 billion euros per year in EU agricultural funding. The first pillar of the CAP, totalling 4.85 billion euros, provides for direct payments to farmers primarily based on the size of their farm. The second pillar supports rural development. Corresponding agricultural, environmental and climate action measures must be cofunded through national budgets. In June 2018, the European Commission unveiled draft legislation for a reform of the Common Agricultural Policy. The next funding period starts in 2021 and ends in 2027.

Due to biological processes in animal husbandry and crop farming, agriculture will not be able to avoid greenhouse gas emissions entirely, not even in the long term. As a result, the remaining emissions must be captured by natural sinks that are attributed to the land use, land use change and forestry (LULUCF) sector.

10

million tonnes of CO_2 equivalents

Within the next ten years, emissions in the agriculture sector are to decrease by ten million tonnes of CO_2 equivalents (15 per cent).

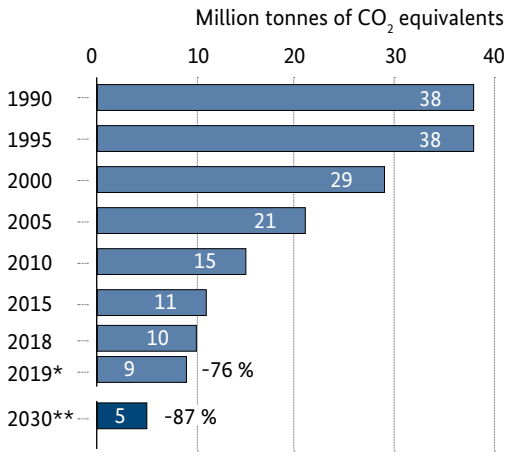
3.7 Waste and recycling management

Emission trends

According to initial estimates, the sector-specific greenhouse gas emissions in waste and recycling management declined by five per cent from 2018 to 2019, to a total of 9.1 million tonnes of CO_2 equivalents. Accordingly, this sector, which also includes wastewater treatment, emits just 1.1 per cent of the greenhouse gases impacting the climate in Germany (Figure 37). In total, almost 90 per cent of the sector's emissions in 2019 were due to landfill gases and wastewater treatment, as in the previous years (Figure 38).

Since 1990, emissions in the waste and recycling management sector have decreased by almost 76 per cent. One key reason for this are the binding technical requirements for waste disposal and recycling introduced in 1993 and 1996, and the 2005 ban on landfilling untreated organic municipal waste. As a result, the methane emissions in waste landfilling have decreased significantly. Further emission savings were primarily made by using waste to generate energy and increasing the recycling rate for materials such as glass, paper, plastics and metals. However, these savings are incorporated in the national climate balance as credits, which are allocated to industry and energy rather than waste management.

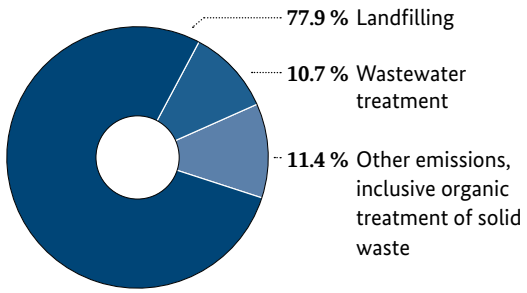
Figure 37: **Emission trends in the waste and recycling management sector and others**



*Estimate **Reduction target compared with 1990

Sources: UBA (2020a), UBA (2020b)

Figure 38: **Emission sources in waste and recycling management in 2018 without CO_2 from biomass**



Source: UBA (2020a)

Areas of action and measures

Within the framework of the Municipal Guideline, provided by the National Climate Initiative, smaller landfill aeration projects have been supported since 2013 to reduce methane emissions in waste management. This support has been expanded and extended until 2030 as part of the Climate Action Programme 2030. In addition, larger landfills will also be supported. It is estimated that the funding measure will reduce emissions by 1.2 million tonnes of CO_2 equivalents annually from 2025 on.

In addition, the Federal Government is also promoting various measures to increase resource efficiency in the industrial sector through its Climate Action Programme 2030. These include material research projects to boost resource efficiency and substitution, for example. Resource substitution involves replacing high-emission materials with lower-emission materials. These measures build on the German Resource Efficiency Programme (ProgRess), which was introduced in 2012 and will be updated for the third time in 2020.

The circular economy concept extends the focus beyond waste management. In 2015, the European Commission unveiled a Circular Economy Action Plan, which had started to implement all planned measures by 2019. The aim of the Action Plan is to make product design, development, use as well as disposal and recyc-

ling as energy-efficient and resource-efficient as possible (Figure 39). The concept therefore spans the entire product life cycle. The Action Plan defines standards for a range of industries, including plastics, food, raw materials, construction, biomass and fertilisers.

In August 2019, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) presented a draft amendment for the German Closed Substance Cycle and Waste Management Act (KrWG). The Act is intended to improve support for the circular economy by imposing stricter recycling rates for many reusable materials. The amendment implements the EU Circular Economy Action Plan.

4

million tonnes of CO_2 equivalents

Within the next ten years, emissions in the waste and recycling management sector are to decrease by four million tonnes of CO_2 equivalents (46 per cent).

The German National Development Bank, the European Investment Bank and four other national development banks have joined forces to provide ten billion euros under the Joint Initiative on Circular Economy. The initiative aims to promote model programmes for the EU Circular Economy Action Plan to support its speedy implementation. To achieve this goal, it supports pilot projects such as creating bioplastic from food waste.

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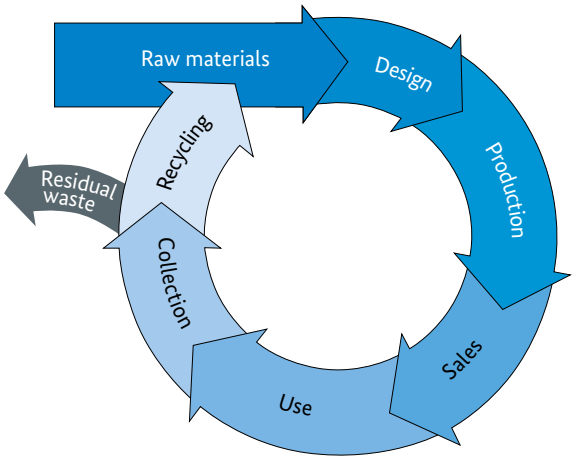
EU Ecodesign Directive

The EU Ecodesign Directive governs the environmentally friendly design of products. This includes not only their energy efficiency, recyclability and reparability, but also harmonising product standards across EU Member States. The directive currently regulates 22 groups of products. If these are to be sold in the European Union, they have to meet the requirements even if they were not made in the EU. The original Directive was adopted in 2005. It is adapted and revised with a new working plan every five years. The next working plan will apply from 2020 to 2024. The Ecodesign Directive and the Energy Consumption Labelling system are now being developed simultaneously for the first time. There will be a change in energy consumption labelling for consumers. From March 2021 on, the scale will return to the original form, with ratings from A to G. There will no longer be A+ to A+++ ratings. The aim is to make these requirements stricter to ensure that there are no products rated A in 2021. In this way, the Directive will help force inefficient products out of the market. The European Commission estimates that 38 terawatt hours of electricity could be saved annually by 2030, equivalent to more than the gross electricity consumption of the Federal State of Hesse in 2018. The Member States are responsible for monitoring and implementing the Directive.

Figure 39: **Circular economy concept**



Source: European Commission (2014)

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

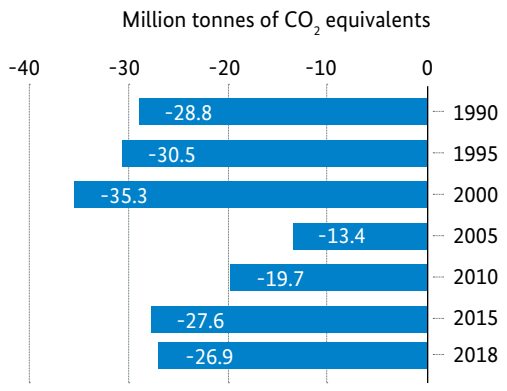
Emission trends

The land use, land use change and forestry sector incorporates the greenhouse effects associated with various types of land use. Depending on the land and forestry use, this sector either emits or stores greenhouse gases. Its emission balance derives from the difference between the greenhouse gases stored and those emitted. Overall, the LULUCF sector serves as a sink for greenhouse gases, reducing Germany's overall emissions in 2018 by 26.9 million tonnes of CO_2 equivalents (Figure 40).

There was a significant leap in the documented sink capacity (ability of nature to absorb greenhouse gases) in land use, land use change and forestry between 2000 and 2005. This development dates back to a change in the method used to determine the sink capacity of forests. Since 2005, the sink capacity in LULUCF has remained relatively constant. Emissions in the sector derive in particular from the conversion of grassland to arable land, from agricultural use of arable land and from the drainage of wetlands. Forests in particular store (bind) CO_2 (Figure 41). However, if no further climate action measures are taken, a significant reduction in sink capacity is forecast for the years to come.[37]

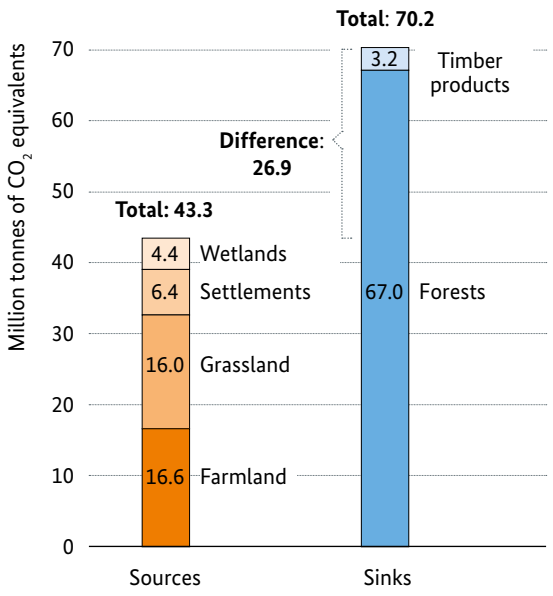
There are targets for the LULUCF sector at both national and European level. The Climate Change Act requires the German government to determine what measures it will take to preserve the net sink capacity of the LULUCF sector. The Federal Government has adopted corresponding measures in the Climate Action Programme 2030. Also at EU level, the LULUCF sector is incorporated in the achievement of the long-term climate targets since 2018 (see Section 2.2).

Figure 40: **Emission trends in LULUCF (including sinks)**



Source: UBA (2020a)

Figure 41: **Emissions and sinks in LULUCF (2018)**



Source: UBA (2020a)

Areas of action and measures

The areas of action in LULUCF include the preservation and improvement of the forests' sink capacity, sustainable forestry management, the use of wood primarily in durable timber products and the preservation of permanent grassland and wetlands. Other relevant areas of action include rewatering of wetlands, soil-friendly farming methods and humus formation in degraded arable soils. Measures mainstreamed in the Climate Action Programme 2030 address these areas of action. The National Biodiversity Strategy (Nationale Strategie zur biologischen Vielfalt) also aims to ensure that forests with natural growth account for five per cent of the woodland in 2020. This figure is currently 2.8 per cent.

At a European level, the land use, land use change and forestry (LULUCF) regulation has laid out stipulations for the sector since 2018. EU Member States are obliged to ensure that their national greenhouse gas balance pertaining to this sector does not deteriorate relative to defined benchmarks in the periods from 2021 to 2025 and from 2026 to 2030. Member States can exchange CO_2 reduction figures (credits and debits) in an accounting system. From 2026 at the latest, managed wetland areas are also to be incorporated in the regulation.

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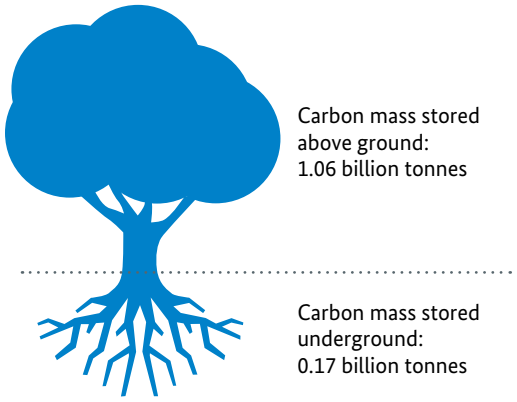
Natural forest growth in Germany

Roughly one third of the German land area is forested. Forests fulfil a wide range of functions for humans and the environment. They also act as a habitat for flora and fauna, and as a recreation area and provider of raw materials for humans. As a sink for greenhouse gases, forests also play a key role in climate action. Overall, German forests bind 1.23 billion tonnes of carbon, the majority of which (1.06 billion tonnes) is stored above ground in trees. A further 0.17 billion tonnes of carbon are stored in the roots (Figure 42). The impacts of climate change are a growing threat to forests. More frequent storms and forest fires, extended droughts and increased infestations with pests (bark beetles) have caused significant damage to forests, especially in recent years. For instance, 2018 and 2019 were extreme years for forest fires. With 1,708 fires and 2,349 hectares of burned land, the 2018 figures were substantially higher than the long-term average (1997 to 2017), which recorded 978 forest fires and 501 hectares of affected woodland. Risk analyses predict a further rise in forest fire risks for Germany for the coming decades. Due to the extreme weather events in recent years, fallen timber has also significantly increased. At 31.9 million cubic metres, it accounted for 49 per cent of overall felling in 2018. Wind and storm events (58 per cent) and insect infestation (35 per cent) primarily accounted for the damage. The Federal Government aims to reforest the damaged areas as quickly as possible. The overall ability of German forests to adapt to climate change is to be increased, with the aim of preserving climate resilient, high-performance mixed forests. Additional objectives include a further expansion of climate action through reforestation, preservation, sustainable forest management and an efficient use of wood.

Figure 42: **Carbon stocks in forests in Germany in 2017**



In total, forests in Germany store 1.23 billion tonnes of carbon. That is equivalent to the absorption of 4,500 million tonnes of CO_2 equivalents.

Source: BMEL (2019)

4. Towards a greenhouse gas-neutral economy and society

Summary

To meet the climate targets under the Paris Agreement, Germany is paving the way to a greenhouse gas-neutral society. This change is already technically feasibly. The aim is to make the change without causing social and economic upheaval. One key prerequisite for this is the creation of sustainable, climate-friendly infrastructures.

Climate action offers businesses opportunities to innovate, modernise and compete internationally. Environmental and climate technologies (GreenTech) are a cornerstone of the German economy and thus already a driver of employment in Germany. A key step towards achieving a greenhouse gas-neutral energy supply is to phase out electricity generation from coal, which will require a structural change in the affected regions (Lusatian, Rhineland, and Central German coal mining areas). This structural change can be implemented successfully with long-term strategies. However, it is at least as important to consistently drive the expansion of renewable energy technologies.

Besides climate action measures taken by the Federal Government, consumer behaviour must also change to reduce greenhouse gas emissions. The financial system needs to be restructured in order to ensure its compatibility with the goal of restricting global warming to no more than 2°C, and pursuing efforts to keep it below 1.5°C.

4.1 Creating sustainable infrastructure

A sustainable infrastructure is the backbone of a greenhouse gas-neutral economy and society. Infrastructure, like transport or power networks, refers to publicly used facilities financed by the government. They enable the economy and society to function. United Nations Sustainable Development Goal 9 sets the goal of creating resilient infrastructures to facilitate sustainable development.

The spread of climate-friendly technologies changes infrastructure requirements. For example, the rapid installation of additional wind energy capacity in Northern Germany requires the expansion of transmission grids to transport the electricity long distances, from its generation in Northern Germany to the consumption hubs in Central and Southern Germany. As a result, the Federal Government has introduced an amendment to the "Transmission Grid Expansion Acceleration Act" to simplify and speed up approval procedures for grid construction projects. The Act entered into force on 17 May 2019. In future, the distribution grids, which transport electricity to end consumers, have to supply climate-friendly technologies with power as well, such as electrically powered heat pumps or electric vehicles. Accordingly, grids have to be expanded or modified for this purpose.

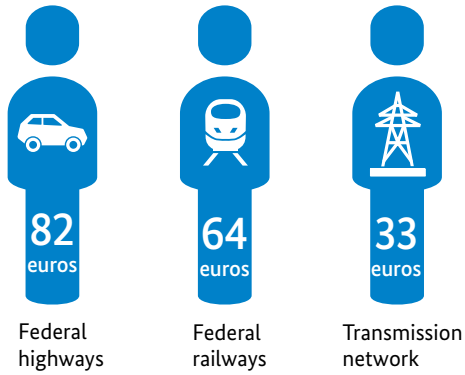
In the mobility sector, key climate-friendly infrastructures include the rail network, cycling paths and charging stations for electric vehicles. The Climate Action Programme 2030 includes a range of measures for their enhancement (Section 3.4).

It is high-performance information and communication infrastructures that enable the use of many climate action technologies in the first place. For example, smart control of power consumption can only be implemented if the control electronics (smart meter) and a fast internet connection are available. The Federal Government aims to provide nationwide coverage for cellular networks and the internet. The roll-out is to be financed from the Special Fund for Digital Infrastructure, among other sources; 6.6 billion euros for the fund was raised through the 5G frequency auction for expansion rights completed in June 2019, which featured multiple telecommunications providers.

At the same time, infrastructures are adversely affected by climate change. Creating sustainable infrastructure also refers to the inclusion of adaptation measures. For example, upgrading wastewater pipelines enhances climate resilience. Given the increasing frequency of torrential rainfalls, the municipal drainage systems must be prepared to handle and dissipate higher volumes of water.

Creating sustainable and resilient infrastructures requires Federal States to undertake major investments. The per capita investments differ substantially: investments in the motorway network currently exceed investments in the long-distance rail network (Figure 43). But what the various infrastructures have in common is their long investment cycles. As a result, the expansion projects for the electricity grid and railway network are planned many years in advance. For this reason, it is important to consistently incorporate climate action in all modernisation projects that need to be carried out anyway, and those that are already in the pipeline. The importance of sustainable infrastructures for climate action and the long-term investment cycles also show how essential it is for the Federal Government to have clear targets.

Figure 43: **Per capita investments in selected infrastructures (2017)**



Sources: BMVI (2020), Federal Network Agency (2020), Destatis (2020)

4.2 Enterprise and innovation

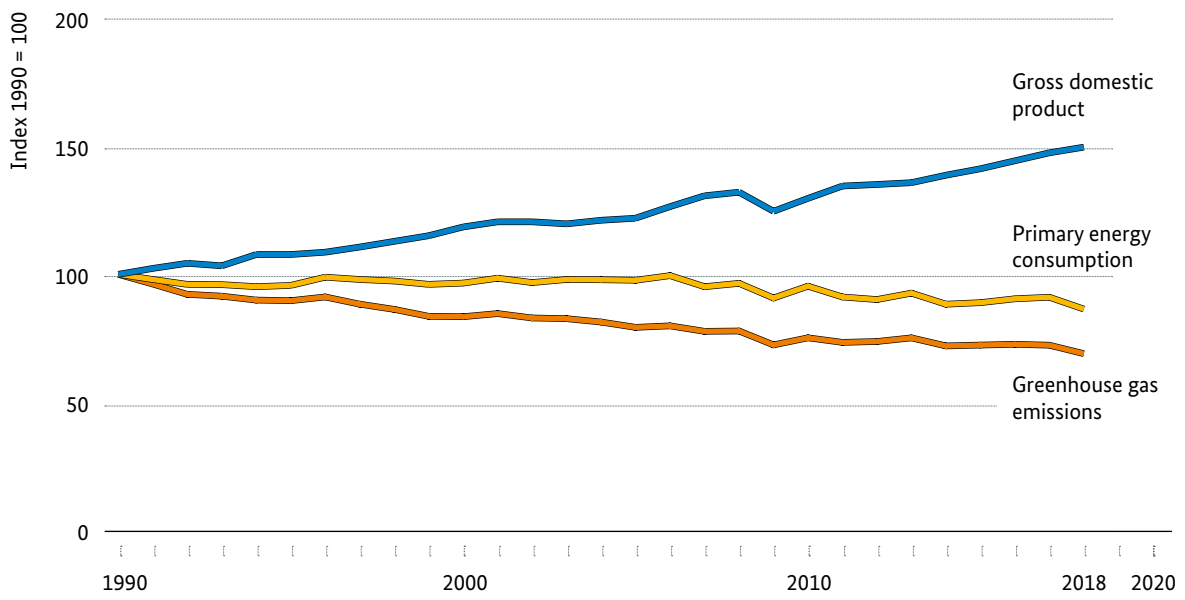
Innovation is a key contributor to achieving climate action targets. To a great extent, the transformation required to achieve the international climate targets can already be implemented with technology currently available. However, this calls for targeted investments, and it often requires a change of mindset too. Transformation enables the economy to create new, sustainable value chains and jobs, as well as tapping new export markets.

Decoupling economic growth, measured by gross domestic product, from greenhouse gas emissions can be considered an indicator for the success of this transformation. Germany is already on the right path in this area. Since 1990, the German economy has grown by 50 per cent while reducing greenhouse gas emissions by 30 per cent (Figure 44). This trend is also apparent in German energy productivity, which measures the ratio of gross domestic product to energy consumption. Energy productivity has risen by over 70 per cent since 1990.[38]

Environment and climate technologies (GreenTech) are an important cornerstone of the German economy. Germany's share of the global market for environmental and efficiency technologies is three times its share of global economic output (Figure 45). Germany holds a particularly large share of the GreenTech market in sustainable mobility (21 per cent), the circular economy (16 per cent) as well as environmentally friendly energy generation and storage (15 per cent). This significantly higher share of the global market in environmental and efficiency technologies compared with its global economic output highlights the importance of GreenTech markets for the German economy. Until 2025, the German GreenTech market is forecast to grow by 8.8 per cent, significantly more than the German economy overall.[39] Annual investments in battery storage highlight this trend: they increased by 48 per cent annually between 2013 and 2017, most recently totalling 466 million euros.[40]

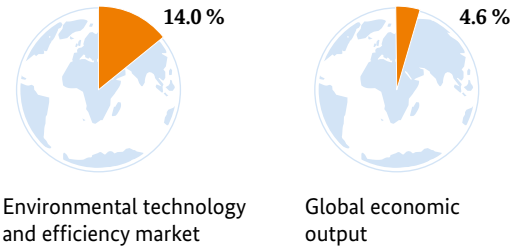
A long-term targeted innovation policy strengthens the GreenTech industry. Accordingly, the German economy has been organising and coordinating various

Figure 44: **Decoupling of growth and greenhouse gas emissions in Germany**



Source: UBA (2019d)

Figure 45: **Germany's global market share (2016)**



Source: BMU (2018)

initiatives. Between 2017 and 2020, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety hosted the "Business meets Climate Action" forum. The forum allowed businesses to network on matters of climate action. The "Medium-sized Company Initiative for Energy Transition and Climate Action" taps energy saving potential at medium-sized enterprises and improves their energy efficiency. The initiative is a cooperation between the Association of German Chambers of Industry and Commerce (Deutscher Industrie- und Handelskammertag e. V.), the German Confederation of Skilled Crafts (Zentralverband des Deutschen Handwerks), the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Some businesses set voluntary greenhouse gas saving targets, becoming climate action pioneers. For example, the Science Based Targets Initiative helps companies formulate scientifically founded savings targets in line with the Paris Agreement. Almost three quarters of skilled craft companies consider climate action important.[41] Over 90 per cent of all companies invest in energy efficiency measures, while affirming their support for additional climate action measures.[42]

> *"Environmental technologies deliver [...] answers to the question of how we can meet the fundamental needs of a growing number of people without further destroying the ecological foundations."*
> *Svenja Schulze, Federal Minister for the Environment, Nature Conservation and Nuclear Safety*

One recent innovation is internal carbon pricing. In this system, a company determines an internal price for its greenhouse gas emissions, which are incorporated in all calculations, business and investment decisions. It provides transparency regarding the social costs of greenhouse gas emissions and the environmental risks of business activities and investments options. Internal carbon pricing allows a company to identify climate-friendly investments more efficiently, helping it make future-proof investment decisions.

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Impacts of climate change on German foreign trade

As the world champion in export, the German economy is particularly dependent on foreign trade. In 2018, Germany exported goods and services with a value of 1.6 trillion euros, or roughly 47 per cent of the entire gross domestic product. This great exposure makes Germany vulnerable to global climate change impacts. As a result, demand for German products in the world could go down, as importing countries suffer the consequences of climate change and economic cycles are disrupted by natural disasters like storms.

Climate change impacts may also make it more difficult to export products from Germany. For example, the lengthy drought in the summer of 2018 led to extreme low water levels on the River Rhine, and caused delivery bottlenecks for many companies.

The effects of climate change are also apparent when it comes to importing products. Extreme weather conditions like drought or flooding, which destroy coffee harvests overseas, can also increase consumer prices in Germany.[43, 44]

4.3 Jobs and structural change

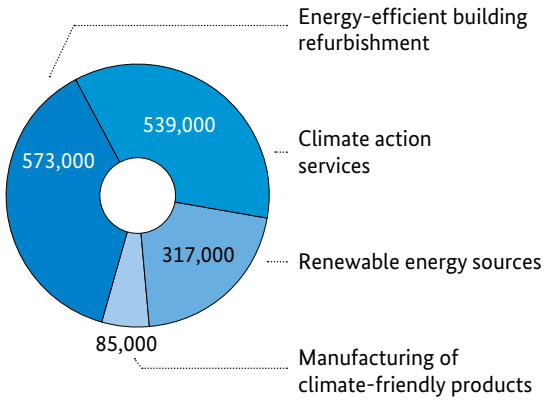
The transition to a greenhouse gas-neutral economy and society will change the way we live and do business. This fundamental transformation brings challenges, but it also offers great opportunities.

Climate action creates jobs and drives employment in Germany. In 2017, roughly 1.5 million people were employed in the German climate action sector (Figure 46). Energy efficiency in particular is a key driver of employment. Investments provided for the energy refurbishment of buildings employed roughly 573,000 people in 2017. More than half a million people work in climate action services. Employers include corporate service providers like architects or engineers who design renewable energy systems. The renewable energy sector employed 317,000 people. A further 85,000 jobs were provided in the production of climate action goods.

Overall, climate action measures will continue to have a positive effect on employment. Until 2030, they are forecast to trigger an additional demand for 307,000 to 427,000 employees.[45] Significant employment growth effects are expected in the sectors trade and other services and construction and finishing trade, among others. On the other hand, job losses are forecast in the lignite industry (mining and power plants). Significant shifts might occur in automotive production. Declining employment in conventional vehicle production will be offset by growth in the production of vehicles with alternative powertrains. In the automotive industry, jobs will also be created in the development and manufacturing of new components, including electric motors, batteries, control electronics and similar items.

Phasing out coal-based generation will change employment structures in some regions. The end of power generation from burning coal is a key element of the energy transition and the shift to greenhouse gas neutrality. In the coal-mining regions, structural changes will occur. It is essential that these do not come at the cost of the standard of living. To drive this positive shift forward, the Federal Government submitted the Structural Development Act (Strukturstärkungsgesetz) in addition to the Coal Phase-out Act (Kohleausstiegsgesetz) to the legislator. It implements the structural policy recommendations of the "Commission on Growth, Structural Change and Employment". The Structural Development Act incorporates financial support for the three major German coal mining areas and for structurally weak municipalities, in which the hard coal sector plays a key economic role.

Figure 46: **Jobs in climate action**



Source: UBA (2019b)

Development concepts for regions facing structural change

To make successful structural changes in the affected regions, dedicated regional development concepts are required. For the three German coal mining regions (Lusatia, Rhineland and Central Germany), general concepts have been set up (Figure 47), which are presented in the section below. They were developed in consultation between the affected Federal States and stakeholders as well as the Federal Government. The concepts aim to turn the regions into attractive and forward-looking economic regions with new value chains.

In order to increase innovation and competitiveness in the region, companies and highly qualified experts will be attracted and supporting infrastructures expanded. One stimulus in this area is provided by the "Competence Centre on Climate Change Mitigation in Energy-intensive Industries" (KEI), which was opened in November 2019. It advises and networks companies on matters related to climate action and greenhouse gas-neutral production. Furthermore, it implements the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety support programme "Decarbonisation in industry".

Lusatian coal mining area
The Lusatian coal mining area forms an energy region located in Central Europe, in which lignite mining has a special historic importance. Measures to enhance the region's ability to add value as part of its development include the relocation of administrative bodies and the creation of high-quality industrial and service jobs in the science and research sectors through existing and new companies.

It will be essential to provide a rapid, regionally significant networking of the entire region with the major cities of Berlin, Leipzig and Dresden, and the regional centres. Via the Dresden-Görlitz/Zgorzelec-Wroclow and Berlin-Cottbus-Weißwasser-Görlitz/Zgorzelec connecting axes, the region will be linked up with the superordinate European connecting corridors.

To secure and increase regional value added, developments are to build on existing skill sets. Key industries in the region include the energy sector, circular economy, mobility, bio-economy, resource efficiency, health and tourism, as well as the semiconductor, chemicals, glass, metal, mechanical engineering and multi-sectoral textile and plastics industries.

Rhineland coal mining area
As a European model region for power supply and resource security, the „Rhineland Region of the Future" project focuses on the sustainable development of industrial value chains in the Rhineland coal mining area.

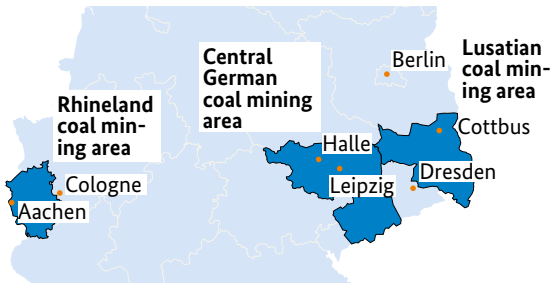
This region is to develop a pioneering culture for new business establishment and growth using systematic knowledge and technology transfer (Innovation Valley Rheinland). Spin-offs with universities and scientific institutions attract new companies to the region, stimulating innovation and education.

Central German coal mining area
In future, the Central German coal mining area is to serve as an international role model, showcasing its transformation towards a sustainable industrial society. It will be an attractive business location and a central industrial hub for the Leipzig/Halle metropolitan region, with the chemical and energy sectors being its structurally predominant cornerstone. The development of a largely greenhouse gas-neutral power supply and the promotion of the circular economy drive value added potential and create industrial jobs.

Thanks to its central location, the Central German coal mining area is also ideally suited for further expansion to become a European logistics hub. With leading international mobility companies and suppliers already located there, research, development and construction is underway around the Leipzig/Halle logistics hub, driving the mobility of the future.

What is more, Central Germany is to become a pioneer for digitalisation. As a region of knowledge, research, transfer and education, the Central German coal mining area offers ideal conditions for this. With its universities and non-university research and education institutions, this region holds a strong potential for the future.

Figure 47: **Coal mining areas in Germany**



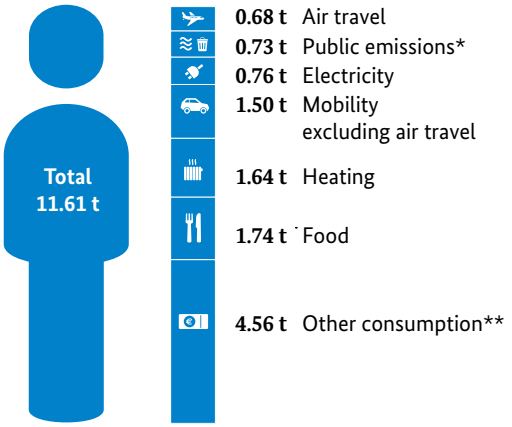
Source: own diagram

4.4 Sustainable consumption

Consumption is an important lever in climate action. For 68 per cent of Germans, climate and environmental action are among the most pressing problems for society. A majority of citizens favour political measures to mitigate climate change and preserve the environment. In 2019, large sections of the public, and in particular many young people, called for far-reaching climate action measures.

More and more people are realising that they can help mitigate climate change through their personal consumer behaviour. The annual per capita greenhouse gas emissions in Germany are 11.61 tonnes of CO_2 equivalents, almost twice the global average (6.66 tonnes of CO_2 equivalents). Roughly 20 per cent of the per capita emissions in Germany are caused by power supply and mobility, including air travel. Food also contributes roughly 15 per cent. Almost 40 per cent of emissions are accounted for by other consumption, which includes clothing and leisure activities (Figure 48).

Figure 48: **Average annual greenhouse gas balance of a person living in Germany in CO_2 equivalents**



*For example: water supply and sewage disposal, waste disposal

**For example: clothing, domestic appliances and leisure activities

Source: UBA (2020d)

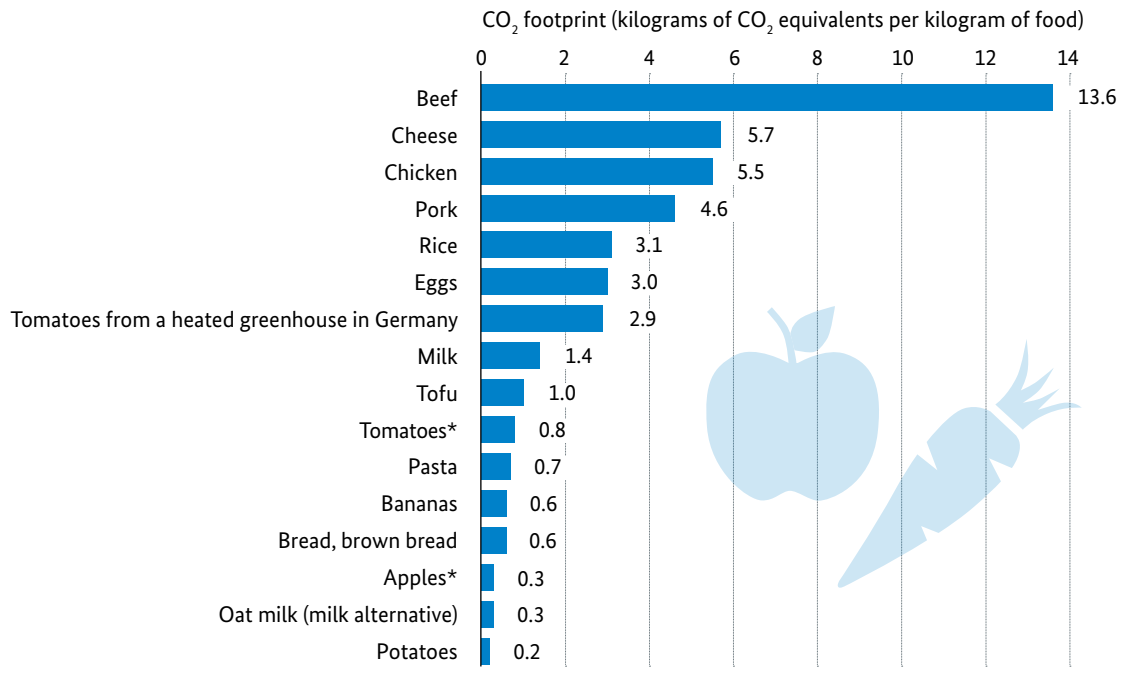
With their consumption decisions, citizens can influence their personal per capita emissions. For example, they can reduce their greenhouse gas emissions by using green electricity, and they can reduce their energy consumption through energy saving measures. It is important to actively combat what is known as the rebound effect. It refers to the increased consumption of a resource in spite of a more efficient use. For example, while a new, larger TV may be significantly more efficient than the older model, its size and potentially more frequent use may ultimately increase overall power consumption.

Food also has an influence on per capita emissions. The climate balance of different types of foods varies significantly (Figure 49). Many animal products like meat and cheese have a high average greenhouse gas balance. Vegetables from heated greenhouses or regional fruit cooled over a period of many months can also have a relatively high carbon footprint. As a result, consuming as much climate-friendly and local food as possible has a positive effect. Examples include regional and seasonal foods. The Planetary Health Diet designed by scientists presents a potential healthy and climate-friendly diet. The proposed nutrition plan keeps both humans and the planet healthy and shows how it could be possible to feed roughly ten billion people on earth with a healthy diet by 2050.

The Federal Government gives tips for a sustainable way of living. For example, it offers advice in its National Programme for Sustainable Consumption. Since 2016, it has described the political framework, identified areas of action and developed solutions to popularise sustainable consumption. To this end, the Federal Environment Agency (UBA) runs the information portal “Environmental tips for every day” (Umwelttipps für den Alltag).

With its consultation processes, the Federal Government helps integrate this approach, next to a diversity of opinions and ideas, into the political process.

Figure 49: **Climate balance of selected foods in Germany**



Source: ifeu (2020)

*Annual average of German consumption

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Global Environment Outlook

In March 2019, the sixth Global Environment Outlook was published and presented at the Fourth United Nations Environment Assembly in Nairobi. The report takes stock of global environmental policy. It emphasises that the targets of the Paris Agreement and the Sustainable Development Goals (SDGs) of the 2030 agenda must be aligned.

For the first time, the report contains regional analyses and thus also an analysis of the implications for Germany. It finds that in spite of considerable environmental policy efforts, Germany too has many environmental problems that are not yet solved. This is evident, among other things, in the stagnation of emissions and in the persistently high level of consumption of natural resources. Consumption and production patterns of German citizens also contribute to exacerbating environmental problems in other countries. These include the production of goods imported to Germany, which caused emissions of 797 million tonnes of CO_2 equivalents in 2015.[46]

The rapid growth of municipal and traffic areas has indirect global effects, as it reduces grasslands and biodiversity. The report recommends that the Federal Government use existing political instruments more consistently and across multiple sectors, and link them with participatory elements to ensure civic support for sustainable climate policy. Another recommendation suggests that the measures be evaluated regularly, based on lessons learned, and that the design be adapted to changing framework conditions.

4.5 Sustainable investments

The Paris Agreement calls for global flows of finance to be aligned with climate-friendly goals. Institutional and private investors continue to invest primarily in companies whose business models are not compatible with the international climate targets. Examples of this include coal, oil and gas companies, as well as cement manufacturers and automobile companies, which have not yet begun to develop low-emission business models. However, to achieve the targets of the Paris Agreement, at least two thirds of the fossil reserves known worldwide must remain unused.

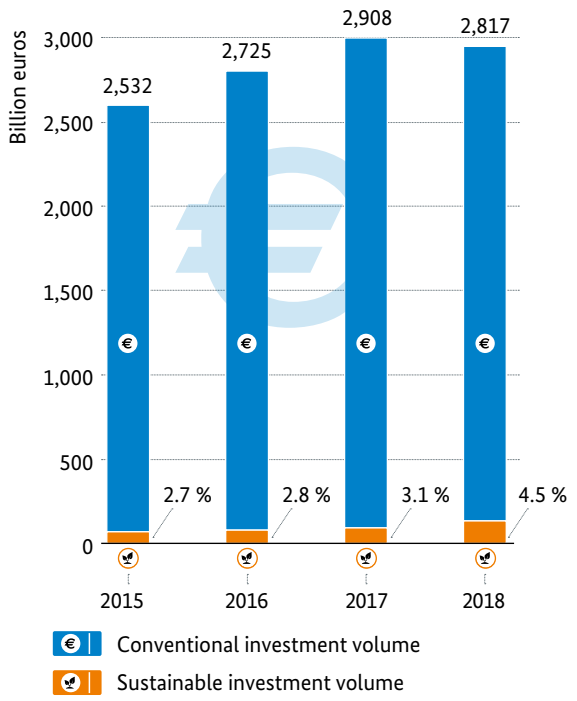
Given the political targets, these investments are increasingly turning into transitory risks. The implementation of climate policy measures can devalue fossil assets instantaneously, which are then referred to as "stranded assets". In a worst case scenario, very abrupt devaluation of such assets can trigger a financial crisis.

Climate change threatens many aspects of the economy, including the financial sector. The financial sector is linked with all other sectors through its function as a provider of funds. Climate change impacts, such as the increasing frequency of extreme weather events, already cause commercial losses of billions of euros. Such risks are referred to as physical risks. However, the financial system has not sufficiently taken these consequences into account to date. As a result, long-term risks must be systematically identified at an early stage, and measures must be taken to mitigate and avoid these risks.

These measures include withdrawing capital from companies whose business models are based on delivering and using fossil fuels (divestment) and investing in climate-friendly companies instead. For example, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) helps cities and municipalities invest their funds and provisions in a sustainable way through its project "Climate-friendly investment – Communal divestment and reinvestment". Another measure is actively influencing companies to develop a company-internal climate strategy (commitment). The challenges of a sustainable financial system include increasing transparency with regard to the climate impact of financial products. This was initiated by the Paris Agreement. Since the end of 2015, the Task Force on Climate-related Financial Disclosures has been working to promote more transparency. The Task Force develops voluntary guidelines that enable companies to report their long-term climate risks to shareholders, investors and insurance providers.

The European Commission presented its action plan for a sustainable financial sector in May 2018. The action plan consists of a comprehensive package of measures that will also be applicable in Germany. Among other things, asset managers like pension funds, insurance companies and banks must report how they incorporate climate risks in their assets. In future, investment advisers will also have to ask customers whether they wish to consider the environmental, social and governance risks (ESG risks) in their investments. As another part of the action plan, the European Commission developed a Europe-wide classification of climate-related criteria for investments and assets (Taxonomy Regulation) in a special working group (Technical Expert Group). This classification was first developed for climate and environmental criteria.

Figure 50: **Share of sustainable financial products in total German investment volume**



Sources: FNG (2019), BVI (2019)

It is to be expanded to other sustainability aspects, like social and governance criteria. As a result, the taxonomy makes it possible to identify environmentally friendly assets and will enable the identifcation of sustainable assets in general moving forward. Upon submission of the taxonomy and the final report of the Technical Expert Group, the European Commission plans to create the EU Platform on Sustainable Finance, which will supervise the development of the taxonomy on a continuous basis. In October 2019, the European Commission also initiated the International Platform for Sustainable Finance (IPSF). Countries involved include Argentina, China, India, Canada and Kenya. The goal of the IPSF is to coordinate international cooperation, initiatives and standardisation for a sustainable financial sector.

As part of the Green Deal, the European Commission also announced a new strategy for a sustainable financial sector, which is to further develop the existing legal framework. The new legislative package will be similar to the first action plan.

The Federal Government intends to make Germany a leading hub for sustainable finance. The Sustainable Finance Council advises the Federal Government on the implementation of its sustainable finance strategy. The Council comprises representatives of the financial sector and the real economy, science and civil society, as well as various federal ministries. The implementation of the sustainable finance strategy is part of the Federal Government's Climate Action Programme 2030. Other measures include the planned release of green federal securities and turning KfW into a transformative development bank.

To implement climate policy measures, the investments required on a Europe-wide basis by 2030 are estimated at 180 to 270 billion euros. Incorporating climate and sustainability risks in investment decisions can help mobilise private funds to fill this financing gap.

The share of sustainable investment volume in overall investments in Germany has risen constantly in recent years (Figure 50). From a baseline of 2.7 per cent in 2015, the sustainable investment volume had increased by 64.5 billion euros to 4.5 per cent of the total investment volume by 2018. This increase indicates the growing interest in sustainable financial investments, both for institutional and many private investors. However, it is also evident that sustainable financial investment still accounts for a very low percentage, and that there is still considerable need for action. That applies both to the identification of sustainable financial products and to redirecting funding to climate-friendly investment options. The Taxonomy Regulation can play a decisive role in both regards.

> ***"Risks to financial stability will be minimised if the transition begins early and follows a predictable path, thereby helping the market anticipate the transition to a two-degree world."***
> *Mark Carney, UN Special Envoy for Climate Action and Finance and former Governor of the Bank of England*

5. Glossary

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

Circular economy
Production and consumption model in which resources are used as sustainably and efficiently as possible. This is achieved by closing energy and material cycles, and through measures to extend use cycles.

Climate impact
Degree of climate-related harmfulness of one molecule of greenhouse gas. The climate impact of carbon dioxide is used as a benchmark, based on which the climate impact of other greenhouse gases is defined. The climate impact of a molecule is expressed in CO_2 equivalents.

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

Cryosphere
Totality of all snow and ice forms (except ice in the clouds) found in the earth's climate system.

Effort sharing
Effort sharing aims to achieve a just distribution of effort in reducing greenhouse gas emissions in European climate policy. It assigns a total emission volume to each individual Member State, which is calculated based on their national per capita income levels.

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

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

F-gases
Fluorinated greenhouse gases (HFCs, PFCs, SF_6 and NF_3) used as refrigerants in cooling and air conditioning systems, as propellants in sprays, foams and insulation materials, and as fire extinguishing agents.

Final energy
The share of primary energy that effectively reaches the consumer after deducting transfer and conversion losses, for example in district heating, electricity, petrol, heating oil, natural gas, biogas and hydrogen.

Fossil fuels
Energy raw materials produced from biomass over millions of years, which consist of carbon compounds of different lengths: oils, coals, gases.

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

GreenTech industry
Economic sectors offering environmentally friendly, sustainable technologies, services and products that save resources and energy.

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

Ice-albedo feedback
Correlation between the global climate and the share of the earth's surface covered with snow and ice, which has a high albedo (reflection capacity). With the decrease of that sun-reflecting share, the absorption of solar energy rises, exacerbating global warming.

NECP
As part of their National Energy and Climate Plans (NECPs), EU Member States must plan their climate and energy targets, policies and measures in an integrated manner and inform the European Commission for a ten-year period.

Plug-in hybrid
Vehicle with a hybrid drive (electric motor and combustion engine), whose battery can be charged by connecting it to the electricity grid or via the combustion engine.

Power-to-X
To store renewable electricity generated at low cost in the long term and allow it to be used in other sectors, an increasing range of different technologies are used to convert (surplus) electricity to other energy sources (Power-to-X). The electricity is converted to hydrogen and methane (Power-to-Gas) or liquid fuels and raw materials (Power-to-Liquid) using additional electricity.

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

Sink
A sink (or carbon sink) is a reservoir that can temporarily or permanently absorb and store carbon. Forests and oceans are major sinks.

Source principle
Allocation of emissions to the point of origin.

Tipping point
Limit which, once exceeded, means that previously valid, constant climatic correlations no longer apply to the climate system. The trends observed prior to the tipping point are abruptly reversed or accelerated.

Transport volume
The transport volume is the product of multiplying mileage by the number of persons transported. It is measured in person-kilometres (pkm) and tonne-kilometres (tkm) in freight transport. Transport capacity is a synonym for the transport volume.

6. Abbreviations

APA	Adaptation Action Plan (Aktionsplan Anpassung)
BMEL	Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft)
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit)
BMVI	Federal Ministry of Transport and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur)
BMWi	Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
BMZ	Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
BWE	German Wind Energy Association (Bundesverband WindEnergie)
C	Carbon
$CaCO_3$	Calcium carbonate
CAP	Common Agricultural Policy
CH_4	Methane
CHP	Combined heat and power
cm	Centimetre
CO_2	Carbon dioxide
COP	Conferences of the Parties
DAS	German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie an den Klimawandel)
DEG	German Development Corporation (Deutsche Entwicklungsgesellschaft)
DWD	German Weather Service (Deutscher Wetterdienst)
EDGAR	Emission Database for Global Atmospheric Research
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EIB	European Investment Bank
EK	Energy concept (Energiekonzept)
ESD	Effort Sharing Decision
ESR	Effort Sharing Regulation
EU	European Union
EU-ETS	EU Emissions Trading System
EUKI	European Climate Initiative (Europäische Klimaschutzinitiative)
EU28	28 Member States of the European Union
Fe	Iron
Fe_2O_3	Hematite (iron(III) oxide), iron ore
Fe_3O_4	Magnetite (iron(II, III) oxide), iron ore
F-gases	Fluorinated greenhouse gases
HFCs	Hydrofluorocarbons
HGV	Heavy goods vehicle
ICCT	International Council on Clean Transportation
ICT	Information and communication technologies
IKI	International Climate Initiative (Internationale Klimaschutzinitiative)
IPCC	Intergovernmental Panel on Climate Change
IPSF	International Platform for Sustainable Finance
KEI	Competence Centre on Climate Change Mitigation in Energy-intensive Industries (Kompetenzzentrum Klimaschutz in energieintensiven Industrien)
KfW	German National Development Bank (Kreditanstalt für Wiederaufbau)
KLiVO	German Climate Preparedness Portal (Klimavorsorgeportal)
KrWG	German Closed Substance Cycle and Waste Management Act (Kreislaufwirtschaftsgesetz)
KSG	Climate Change Act (Klimaschutzgesetz)

KSPr 2030	Climate Action Programme 2030 (Klimaschutzprogramm 2030)
LED	Light emitting diode
LULUCF	Land use, land use change and forestry
NDCs	Nationally Determined Contributions
NECP	National Energy and Climate Plan
nETS	National Emission Trading Scheme
NF_3	Nitrogen trifluoride
NKI	National Climate Initiative (Nationale Klimaschutzinitiative)
N_2O	Nitrous oxide
PFCs	Perfluorocarbons
Pkw	Passenger car (Personenkraftwagen)
ProgRess	German Resource Efficiency Programme (Deutsches Ressourceneffizienzprogramm)
PtX	Power-to-X
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDG	Sustainable Development Goals
SF_6	Sulphur hexafluoride
t	Tonne(s)
UBA	Federal Environment Agency (Umweltbundesamt)
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
WLTP	Worldwide Harmonized Light Vehicles Test Procedure

7. Endnotes

1. UBA (2019c)
2. IPCC (2018)
3. IPCC (2019a)
4. IPCC (2019b)
5. PIK (2020)
6. UBA (2008)
7. UBA (2020f)
8. Germanwatch (2020)
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12. EEA (2019a)
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14. EEX (2020)
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16. AG Energiebilanzen (2019)
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19. Prognos AG, Fraunhofer ISI, GWS, iinas (2020)
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22. BMEL (2019b)
23. Deutschland in Zahlen (2020)
24. UBA (2020g)
25. ICCT (2019)
26. BMU (2019a)
27. BMVI (2020c)
28. Destatis (2020a)
29. dena (2019a)
30. EEA (2019b)
31. Initiative Deutschland-Takt (2020)
32. Federal Government (2019b)
33. Federal Government (2019c)
34. UBA (2020g)
35. UBA (2019d)
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9. Data appendix

Data appendix for Figure 09: **Federal Government energy and climate targets**

	Status quo (2019)*	Targets 2020	2030	2040	2050	Sources of the targets
Reduction of overall greenhouse gas emissions compared with 1990						
Overall emissions	-35.7 %	At least -40 %	At least -55 %	At least -70 %**	Green-house gas neutrality	2020 to 2040: EK (2010) 2050: KSG (2019)
Energy	-45.4 %		-62.5 %			KSG (2019)
Buildings	-33.9 %		-50.6 %			KSG (2019)
Transport	-0.3 %		-42.0 %			KSG (2019)
Industry	-42.0 %		-66.6 %			KSG (2019)
Agriculture	-24.2 %		-35.5 %			KSG (2019)
Others	-75.6 %		-86.9 %			KSG (2019)
Renewables						
Share of gross final energy consumption	17.1 %	18 %	30 %	45 %	60 %	EK (2010)
Share of gross electricity con-sumption	42.1 %	35 %	65 %	**	**	EK (2010), KSPr 2030 (2019)
Share of heat consumption	14.5 %	14.0 %				EEWärmeG (2015)
Share in the transport sector	5.6 %	10.0 %				EU Directive 2009/28/EC
Efficiency and consumption						
Primary energy consumption (compared with 2008)	-10.8 %	-20 %			-50 %	EK (2010)
Final energy productivity (2008 to 2050)	+1.6 % (2008 to 2017)	+2.1 % per year (2008 to 2050)				EK (2010)
Gross energy consumption (compared with 2008)	-6.7 %	-10 %			-25 %	EK (2010)
Primary energy consumption of buildings (compared with 2008)	-18.8 % (2017)				-80 %	EK (2010)
Heating requirements of build-ings (compared with 2008)	-6.3 %	-20 %				EK (2010)
Final energy consumption of transport (compared with 2005)	+6.1 % (2018)	-10 %			-40 %	EK (2010)

EEWärmeG: Renewable Energy Heat Act, EK: Energy Concept, KSG: Climate Change Act, KSPr 2030: Climate Action Programme 2030

*Estimate

**In light of the greenhouse gas neutrality target for 2050 and a complete decarbonisation of the energy and electricity supply in Germany, the targets set in the 2010 energy concept for 2040 and 2050 must be raised accordingly.

Sources: UBA (2020b), UBA (2020i), UBA (2020h), BMWi (2010), Federal Government (2019a), Federal Government (2019b), Federal Government (2015)

Data appendix for Figure 14: **Greenhouse gas emission trends and envisaged annual emission quantities by sector in million tonnes of CO_2 equivalents**

Greenhouse gas emission trends by sector

Sector	1990	1995	2000	2005	2010	2015	2018	2019
Energy	466	400	385	397	368	347	322	254
Industry	284	244	208	191	188	187	195	188
Transport	164	177	181	160	153	162	162	163
Buildings	210	188	167	154	149	125	117	122
Agriculture	90	76	75	70	70	74	70	68
Waste management and others	38	38	29	21	15	11	10	9

Annual emission quantities per Annex 2 to the Climate Change Act

Sector	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy	280		257								175
Industry	186	182	177	172	168	163	158	154	149	145	140
Transport	150	145	139	134	128	123	117	112	106	101	95
Buildings	118	113	108	103	99	94	89	84	80	75	70
Agriculture	70	68	67	66	65	64	63	61	60	59	58
Waste management and others	9	9	8	8	7	7	7	6	6	5	5

Sources: UBA (2020a), UBA (2020b), Federal Government (2019)

www.bmu.de/english