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Climate Action in Figures

Facts, Trends and Incentives for German Climate Policy
2019 edition

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Foreword

The extremely hot summer of 2018 showed us that, in Germany too, climate change is already a reality. With a view to achieving international and European climate targets, the German government wants to play an active part in mapping the route to a greenhouse gas neutral society. We want to secure a liveable world for future generations.

The 24th United Nations Climate Change Conference (COP24) in Katowice in 2018 adopted a rulebook for implementing the Paris Agreement. We now have the first minimum standards for reporting greenhouse gas emissions that are binding for all parties. Previously, only developed countries were subject to these rules. This is an important step for lowering global greenhouse emissions. Within Europe, reforms have significantly strengthened the emissions trading system, a key instrument. Moreover, in 2018 the European Commission presented its strategic long-term vision for a climate-neutral Europe. Germany adopted its own strategy, the Climate Action Plan 2050, in 2016. This is geared to the global principal of greenhouse gas neutrality and to achieving the European climate targets.

The Climate Action Plan 2050 provides guidance for the transition to a greenhouse gas neutral economy and society, but does not specify all the details and acknowledges the need to consider future developments. We must also bear in mind the impacts our climate policy may have on social structures and the economy. I find it most encouraging that more and more companies and industry associations are addressing climate change and recognising that ambitious climate action is a driver of innovation, while unchecked climate change represents a growing threat to humans, capital and infrastructures. To facilitate implementation of the Climate Action Plan, we have underpinned it with programmes of measures. The Christian Democratic Union (CDU), Christian Social Union (CSU) and Social Democratic Party of Germany (SPD) have furthermore agreed to adopt a climate change act during this legislative period. By establishing the Climate Cabinet, which met in April 2019 for the first time, the Federal Chancellor made it clear that climate action is a high-level, priority issue.

In my view it is vital that we bring everybody in this country on board. We can do that by shaping climate policy together in dialogue. The work of the Commission on Growth, Structural Change and Employment was a good example of how this can be done effectively. The commission's recommendations pointed the way towards a gradual phase-out of coal-based power, while also developing prospects for the people in the regions affected.

Facts and figures are an important basis for political decision-making. The annual data on developments in greenhouse gas emissions act as a compass by which to steer our climate policy. Each year, we make these figures and a range of other climate data available to the public in our brochure Climate Action in Figures. The 2019 edition presents and explains all the latest climate information and gives an overview of Germany's comprehensive climate policy.

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

Since the beginning of industrialisation, the global mean temperature has **risen by around 1°C** because of climate change. Every decade, the earth is warming by **0.2°C** as a result of climate change caused by humans. The Intergovernmental Panel on Climate Change (IPCC) warns that global warming of more than 2°C by 2100 compared to pre-industrial levels can have serious consequences. Unless harmful greenhouse gas emissions are restricted, the global mean temperature is likely to rise by **more than 3°C**. The negative consequences of climate change include more frequent droughts, rising sea levels and a loss of biodiversity. As one of the world's largest economies, Germany has contributed almost five per cent to global warming since the dawn of industrialisation.

In 2018, annual per capita carbon dioxide (CO_2) emissions in Germany, at around 9.6 tonnes, were still about twice the international average of 4.8 tonnes per capita.

Germany is being increasingly affected by the impacts of climate change. The average temperature in Germany has risen by 1.5°C, far more than the global average. The impacts of climate change are expected to intensify in the future, and further action will be needed to adapt to climate change. Germany therefore passed the **German Climate Change Adaptation Strategy (DAS)** in 2008. The European Union (EU) adopted a strategy on adaptation to climate change in 2013.

1.1 Climate change – causes and consequences

Climate change is one of the greatest challenges facing humankind. The anthropogenic greenhouse effect is causing the earth's atmosphere to warm faster than ever before, with many irreversible impacts on people and the environment. Since the start of industrialisation, the global mean temperature has risen by around 1°C. Human activities producing greenhouse gas emissions are primarily responsible for this increase. The most significant greenhouse gas is CO_2, which is formed mainly when fossil fuels are burned. Since 1850, the global atmospheric CO_2 concentration has risen by 44 per cent compared to the previous 10,000 years.[1] Industrialised countries like Germany have particularly high average per capita greenhouse gas emissions (see also Figure 05 in Section 1.3).

Without additional measures to combat climate change, it is likely that the global temperature will rise by more than 3°C. This would have drastic consequences; for example, coastal regions and island nations could be flooded. Even if the temperature rises by between 1.5 and 2°C, the impacts of climate change will be clearly felt (see Spotlight). For example, record temperatures are already occurring globally five times more frequently than would be expected without climate change.[2] The impacts of climate change vary by region. In some regions – such as the Arctic – the observed temperature increase to date is two to three times higher than the global average of around 1.5°C (Figure 02).[3] Progressive warming has been accompanied by an increase in the strength and frequency of extreme weather events. Tropical cyclones are becoming stronger because of global warming. The rise in sea levels continues to accelerate globally, while high mountain glaciers are melting, leading to water shortages in the surrounding regions. More and more people could be forced to leave their homes because of climate change.

Figure 02 shows the temperature trend from 1880 to 2018 and the deviation from the historical frame of reference in Germany. Compared to pre-industrial levels, the annual mean temperature has risen by 1.5°C. For this comparison, climate scientists usually take 1880 as the reference year or the period 1850 to 1900 as the historical frame of reference, as this is

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How greenhouse gases are formed[4]

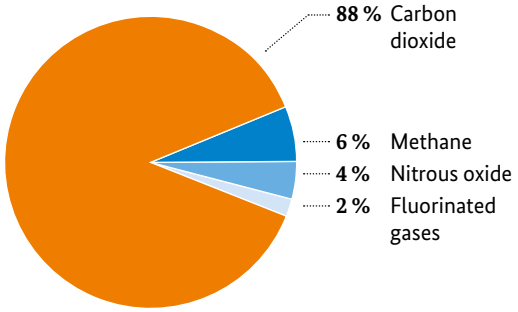
Carbon dioxide (CO_2) is an odourless and colourless gas that persists in the atmosphere for an average of 120 years. It is produced mainly as a by-product of burning fossil fuels such as coal, oil and gas. In recent years, there has been an increase in the use of wood for fuel, which also produces high CO_2 emissions. This is not reported in the energy sector, however, as the emissions are counted when the wood is harvested in the forest. Particularly in the tropics, deforestation and slash-and-burn agriculture are highly significant, since forests store up to 70 per cent of the CO_2 on earth.

Methane (CH_4) is formed when organic matter breaks down anaerobically (without air). This occurs in agriculture and forestry, and in the stomachs of animals. Sewage treatment plants and landfills are another source. Methane is around 25 times more potent as a greenhouse gas than CO_2.

Nitrous oxide (N_2O) only occurs at trace levels in the atmosphere but is 298 times stronger as a greenhouse gas than CO_2. Nitrous oxide enters the atmosphere via nitrogen fertilisers and intensive livestock farming as well as chemical processes in industry.

Fluorinated gases (hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), SF_6 and NF_3) are synthetic gases that are used as propellants, refrigerants or solvents. The proportion of F-gases in emissions in Germany is low, but their greenhouse effect is 100 to 24,000 times stronger than CO_2, due in part to their extremely long persistence in the atmosphere.

Figure 01: **Shares of greenhouse gases in Germany in 2017 in CO_2 equivalents**



Source: UBA (2019a)

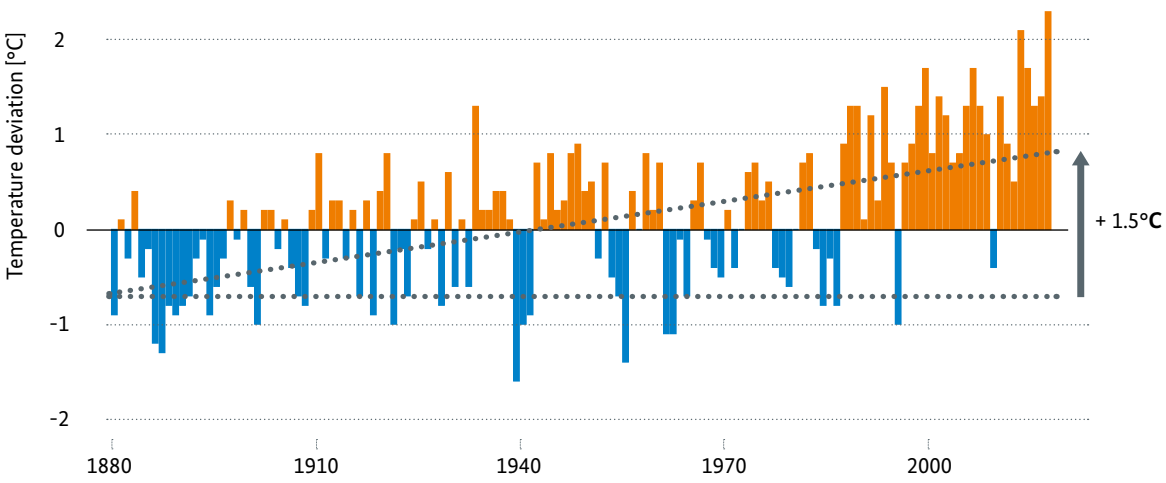
the earliest period for which sufficient temperature observations are available. Temperature variations are shown together with multi-year average values for comparison. The graph is based on the internationally applicable reference period of 1961 to 1990 with a reference value of 8.2°C for the annual mean temperature in Germany.

Germany is being increasingly affected by the impacts of climate change. In Germany, the main risks are extreme heat and droughts, heavy rainfall and resulting floods. The cold periods in winter are becoming shorter, while summer heat waves are happening more often. The latter are dangerous mainly to the elderly, people with pre-existing medical conditions, and children. In large cities, heat builds up more because of the high level of surface sealing and high density of buildings.

Changes in the climate have direct impacts on various sectors of the economy. In 2018, agriculture was particularly hard hit by extreme climate events. The impacts were also felt in other areas; for example, there were limitations on shipping on German rivers.

Climate change can upset the balance of native ecosystems. Higher temperatures and changes in seasonal weather patterns affect the composition of species communities. Between 5 and 30 per cent of native species in Germany could be lost over the coming decades because they are unable to adapt

Figure 02: **Temperature trend and deviations in Germany since 1880**



Source: DWD (2019)

0.2°C

Anthropogenic climate change is currently causing the earth to warm by 0.2°C per decade.

to changing environmental conditions. Climate change-induced temperature effects are a particular threat to cold-water fish and crab species as well as yellow-bellied toads and sedgelings, whose habitats depend on moist conditions. Conversely, the spread of animal and plant species that are not originally native to Germany may be a threat to human health and cause high economic costs.

> ***"2018 was the year of climate change."***
> ***Andreas Friedrich, Press Spokesman, German Meteorological Service (DWD)***

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Another year of extreme weather

With an average temperature of 10.5 °C, 2018 was the warmest and sunniest year in Germany since weather records began. In Frankfurt am Main, for example, thermometers passed the 30°C mark on 19 consecutive days in the summer of 2018. Thirteen "tropical nights" were recorded too, where the temperature did not fall below 20 °C. Across Germany there were 74 summer days with temperatures over 25 °C. That is 12 more days than in the record summer of 2003. 2018 was also one of the lowest rainfall years since 1881. Precipitation in Germany in 2018 was only around 60 per cent of the usual level.

April to November were exceptionally dry months, bringing extreme drought to some areas. In the agriculture sector, this resulted in regional potato and cereal yield losses of up to 75 per cent.[5] Low water levels on the Rhine meant that power stations had to cut their output, otherwise the cooling water would have raised the temperature of the river. Cargo ships had to sail with reduced loads, leading to raw material shortages. Industrial firms had to cut back production, and there were supply bottlenecks at filling stations.

Climate change does not mean that every summer from now on will be so hot. But there is a greater probability of extreme heat events in summer. Almost every year since the turn of the millennium has been warmer than previous decades, often accompanied by unusually high or low precipitation volumes. The number of extreme weather events in Germany has more than tripled in the past 50 years.

SPOTLIGHT 2019: IPCC special report on global warming of 1.5°C

The IPCC compiles the world's latest knowledge on climate change. Under the auspices of the United Nations, the IPCC produces state of knowledge and special reports at regular intervals. For these reports, hundreds of scientists from around the world evaluate the available studies. IPCC reports reflect the internationally acknowledged current state of climate change research. The IPCC was established in 1988 by the United Nations Environment Programme and the World Meteorological Organization.

The October 2018 IPCC special report on global warming of 1.5°C serves as the scientific basis for the risk assessment of global warming of 1.5°C. With the signing of the Paris Agreement in 2015, the IPCC was asked to present a special report on the impacts of global warming by 1.5°C compared to pre-industrial levels and the associated greenhouse gas emission paths. Scientists from more than 44 countries evaluated over 6,000 studies for the report. Formally adopted by the Member States in 2018, the special report serves as a basis for assessing the climate action efforts agreed so far by members of the United Nations Framework Convention on Climate Change (UNFCCC). The special report therefore also provides a framework for the global climate policy debate.

Considerable climate impacts already occur with global warming of 1.5°C. The special report shows that the risks of climate change to humans and nature are even greater than was previously thought. Even if global warming is limited to 1.5°C, there will be a marked increase in extreme events such as heat waves, heavy rains and droughts in some regions. Sensitive ecosystems like tropical coral reefs are particularly threatened by rising temperatures. Compared to global warming of 2°C, the expected impacts of a 1.5°C temperature increase are generally less severe. Furthermore, above 1.5°C it is possible that the climate system will reach tipping points. Figure 03 compares the consequences of a 1.5°C rise in temperature with a 2°C rise.

Without further action, the global temperature increase will reach 1.5°C between 2030 and 2052. Compared to pre-industrial levels, the increase in the global mean temperature due to human activity is already around 1°C. Many changes in the climate system have been demonstrated, including more frequent extreme weather events and rising sea levels. Limiting global warming to 1.5°C requires a radical reduction in greenhouse gas emissions. From the middle of the century, no more greenhouse gases should be emitted than can be absorbed (zero net emissions). Achieving this goal will require rapid and far-reaching changes in all sectors over the decades ahead. By 2030, anthropogenic CO_2 emissions will have to be cut by around 45 per cent compared to 2010 levels.

The climate action that has been planned so far is not sufficient to meet the goals of the Paris Agreement. Even if countries around the world implemented the climate actions they have announced to date, global warming would still exceed 2°C. So there is a need for additional systematic and comprehensive reduction activities in all sectors. The special report also highlights the need to recapture CO_2 that has already been emitted. Ecosystem-based methods such as reforestation are discussed along with technological solutions, such as separating and storing airborne carbon. However, a lot of research remains to be done regarding the total potential, costs and risks of CO_2 capture and storage.

> *"Everything we do from now on matters. If we can cut global CO_2 emissions by 45 per cent by 2030 compared to 2010, we are probably in a good position to limit global warming to 1.5°C." Hoesung Lee, Chair of the IPCC*

The special report also discusses the tensions between climate action and poverty, or possible synergies and conflicts with the United Nations, including Sustainable Development Goals. For example, the number of people who are both exposed to climate-related risks and at risk of poverty is several hundred million lower with global warming of 1.5°C by 2050 than with a 2°C rise in temperature.

Figure 03: **Comparison of selected climate impacts given a 1.5°C or 2°C rise in global mean temperature compared to pre-industrial levels**

Aspect	Consequences		Temperature increase of 1.5°C	Temperature increase of 2°C
Freshwater	Drought	Additional urban population exposed to severe drought	Around 350 ± 159 million	Around 411 ± 214 million
	Fluvial flood	Increase in population affected by fluvial floods (compared to 1976 to 2005)	100 %	170 %
Terrestrial ecosystems	Biodiversity loss	Insects losing more than half of their habitat (percentage)	Around 6 %	Around 18 %
		Plants losing more than half of their habitat (percentage)	Around 8 %	Around 16 %
		Vertebrates losing more than half of their habitat (percentage)	Around 4 %	Around 8 %
Ocean	Rising sea levels	Rise by 2100	By up to around 1 m*	Around 10 cm higher than for 1.5°C*
	Sea ice free Arctic summers	Frequency	About every 100 years	About every 10 years
	Loss of tropical coral reefs	Percentage lost	70 to 90 %	Over 99 %
	Declining fish stocks	Fall in annual sea fishery yields	Around 1.5 million tonnes	Over 3 million tonnes
Coastal areas	Consequences of rising sea levels and increased storminess	Number of people affected (without flood defences)	Around 128 to 143 million	Around 141 to 151 million
		Number of people affected (with flood defences of 1995)	Annually around 2 to 28 million	Annually around 15 to 52 million

* The instability of the polar ice sheets could result in an additional rise in sea levels by several metres over a period of hundreds to thousands of years.

Source: own chart based on IPCC special report on global warming of 1.5°C

1.2 Climate preparedness – adaptation to climate change

Because the impacts of climate change will continue to intensify in the future, there is an increasing focus on taking action to adapt to climate change. Climate policy pursues two main goals. Firstly, greenhouse gas emissions should be limited to prevent the global mean temperature rising by more than 2°C. Secondly, adaptation to climate change is about anticipating and taking appropriate steps to prepare for and mitigate the impacts of climate change. Adapting to climate change means becoming resilient and capable of transformation. Certain positive effects of climate change (such as reduced heating demand in some areas due to milder winters) do not come close to outweighing the many negative impacts of climate change.

Adapting to climate change in time will result in lower overall costs. It is also important to realise that the greater the increase in global mean temperature, the higher the costs of damage and adaptation will be. The need to adapt to the consequences of climate change was recognised early on. In the 1990s, the international community adopted a framework for climate adaptation – the UNFCCC. Financing adaptation measures was made part of the Paris Agreement. The Adaptation Fund is used in particular to benefit vulnerable island nations and developing countries. In 2013, the EU adopted a strategy on adaptation to climate change to increase the resilience of EU countries, regions and cities.

Figure 04: **Challenges in Germany in terms of vulnerability to threat types and regions**

Increased heat stress

Adaptation measures: create green corridors in cities, provide a heat wave warning system for vulnerable groups, improve drinking water availability during hot periods.

Where: urban areas in the warmer regions of Germany, such as Berlin, Cologne, Frankfurt am Main (will continue to expand).

Elevated forest fire risk

Adaptation measures: create suitable mixed forests, forest fire prevention, effective forest fire fighting.

Where: regions with extensive woodland and forest management in eastern Germany and low mountain ranges.

Change in species composition and natural developmental stages

Adaptation measures: habitat optimisation for endangered species, afforestation, systematic attention to climate functions of soil.

Where: seas and rural areas.

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

Adaptation measures: improve forecasts for climate, extreme weather and floods, raise flood defences.

Where: coastal areas.

Heavy rain and flash floods

Adaptation measures: climate-resilient infrastructure, optimisation of dams, reservoirs and detention basins.

Where: urban centres in the lowlands of north-western Germany, low mountain ranges and south-western Germany.

Impairment of water use due to increasing warming

Adaptation measures: reduce water extraction by energy sector and industry.

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

River floods

Adaptation measures: renaturation of watercourses and alluvial plains, create detention basins and infiltration areas.

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

Source: Federal Government (2015)

The DAS was passed in 2008. It defines the key goals and options for adaptation; specific measures were set out in the 2011 Adaptation Action Plan I (APA I) and in 2015 in the first DAS progress report.[6] These measures cover different policy areas, such as transport, construction and health, and range from funding mechanisms and research activities to legislative provisions. With the first DAS progress report, climate change was recognised as a permanent task for the Federal Government, and an ongoing climate adaptation reporting system was established. The first DAS evaluation report will be published in 2019.

The Federal Government supports research on improving weather models and gaining better data on climate change impacts and adaptation. Detailed predictions of the geographical distribution of negative impacts are important so that economic and social harm can be prevented through adequate preparation. In the first instance, action to mitigate climate change should take place where Germany is particularly vulnerable to and affected by climate change (Figure 04). Adaptation measures are therefore implemented primarily at local or regional level.

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German Climate Preparedness Portal

Climate preparedness requires a fact-based understanding of climate change and the best possible predictions of climate change impacts. Cooperation by businesses, planners at municipal and state level, and the public at large is also important. This is where the Federal Government's Climate Preparedness Portal comes in. The portal catalogues quality-assured climate preparedness services that provide climate data and information, for example, as well as adaptation services to help manage climate impacts. The services are targeted at the national level as well as at the Federal States, districts and municipalities that are dealing with and preparing for the individual impacts of climate change, for example in the context of action programmes or adaptation strategies. Many services are also suitable for civil society, businesses and private citizens.

Climate information comprises meteorological and climatological data including temperature, precipitation, wind, soil moisture and sea temperature. This data and information about the climate system in the past, present and future can be combined with other information (such as socio-economic scenarios, demographic change) and incorporated into risk and vulnerability analyses. In this way, it is possible to assess which sectors and regions are particularly affected. For example, urban planners can use temperature and precipitation data, land-use plans and population trend data to predict locations where extreme heat or heavy rain could become dangerous for people and infrastructures. Then they can implement counter-measures. By doing this, they are supporting climate adaptation services.

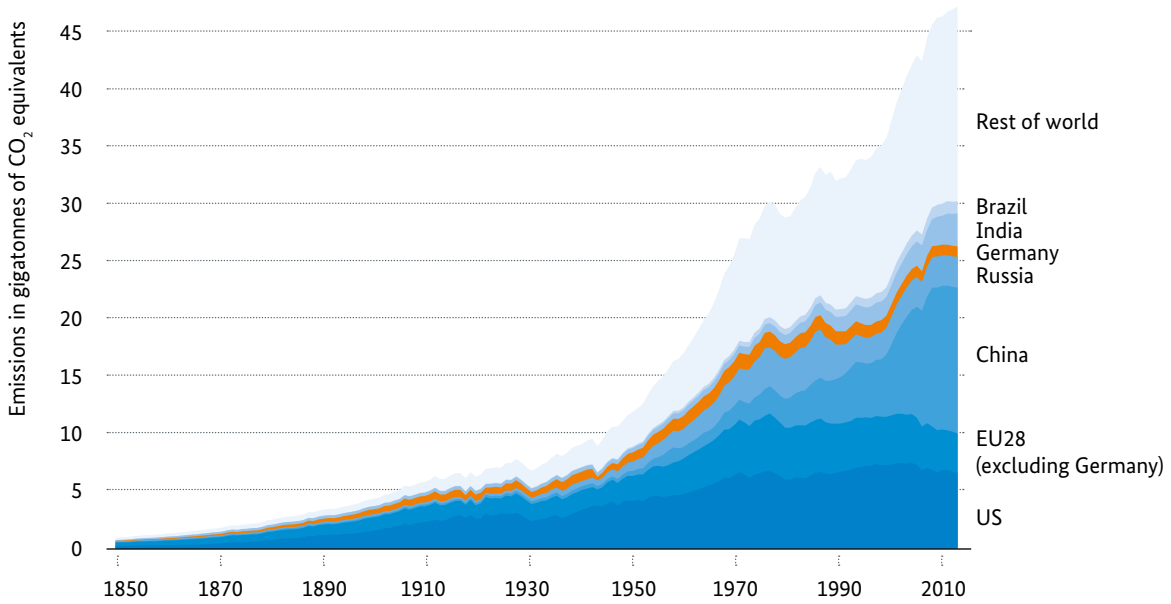
Climate adaptation services show how municipalities, associations or businesses are factoring climate impacts into their decisions and planning, and what adaptation measures they can implement. By providing guides, web tools, maps or training opportunities, climate adaptation services assist in selecting, planning and implementing measures, and evaluating their effectiveness.
For more information about the Climate Preparedness Portal, visit www.klivoportal.de

1.3 Global responsibility and opportunities for a sustainable future

Industrialised countries bear special responsibility for climate change. Since the start of industrialisation, Germany has emitted almost five per cent of global greenhouse emissions.[7] Given the threatening impacts on people and the environment, Germany therefore has a special responsibility to combat climate change.

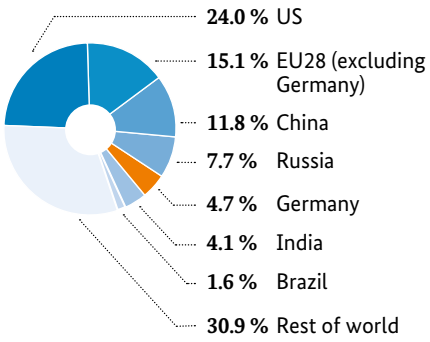
In recent decades, emissions have grown mainly in the burgeoning economies of the emerging countries. China has emitted more greenhouse gases than the United States since 2005 and currently continues to occupy top place among the biggest greenhouse gas emitters, with 11 billion tonnes of CO_2 equivalents. It should be noted that annual per capita emissions in developing and emerging economies are much lower

Figure 05: **Global greenhouse gas emissions**

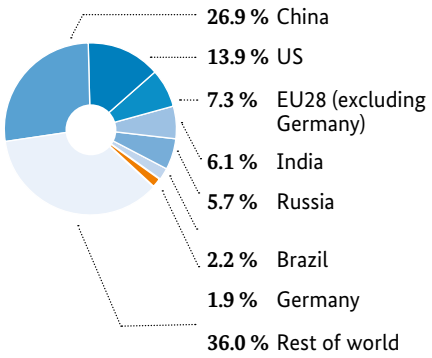


Individual data points can be found in the table in the appendix on page 66.

Shares of historical total emissions

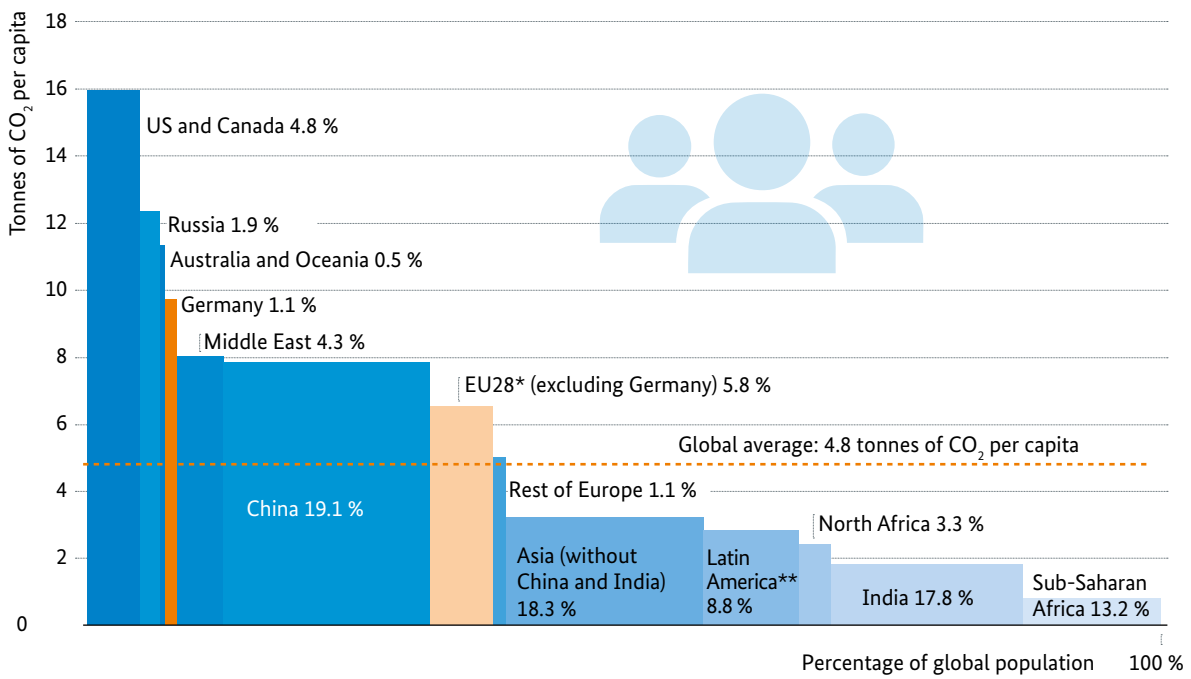


Greenhouse gas emissions 2016



Source: PIK (2019)

Figure 06: **Per capita CO_2 emissions in selected regions by share of global population in 2017**



* Including Monaco, San Marino, Andorra

** Including the Caribbean
Breakdown according to UN Statistics Division

Source: own graph based on EDGAR (2018)

than in industrialised economies. In Germany, per capita CO_2 emissions are around 20 per cent higher than in China, around five times higher than in India, and roughly twice the global average (Figure 06).

With its Climate Action Plan 2050, Germany is one of the first countries to put forward a long-term strategy with sector-specific targets. The plan identifies ways in which all sectors can be almost completely decarbonised by 2050. Section 2.3 presents further details on Germany's climate policy.

Successful implementation of climate targets in Germany sets an important example. If Germany – an economically powerful and prosperous country – can take successful climate action, it sends a strong signal to other industrialised as well as developing and emerging countries. Their commitment to climate action is essential so that global warming can be limited.

Numerous international energy dialogues and partnerships with countries such as China and India are already facilitating experience sharing and helping to promote a sustainable global energy supply.

3°C

The earth would experience warming of 3°C by the end of this century if every signatory country to the Paris Agreement implemented its national contributions. The parties to the agreement therefore need to take more climate action to achieve the goals agreed on in Paris.

2. Climate action goals and instruments

Summary

With the goal of limiting climate change, 184 countries and the EU have ratified the **Paris Agreement**. Under the UNFCCC, the international community made a commitment in 2015 to limit global warming to **well below 2°C** and preferably to less than 1.5°C compared to pre-industrial levels.

As a contribution to the Paris Agreement, the EU Member States have undertaken to jointly reduce greenhouse gas emissions by **at least 40 per cent** by 2030 compared to 1990. The EU is working to develop its climate and energy policy to reach this goal.

By 2050, EU-wide greenhouse gas emissions are to be reduced by **80 to 95 per cent** compared to 1990.

Germany defined its own climate milestones in the Climate Action Plan 2050. It identifies ways that Germany can become largely greenhouse gas neutral by the middle of the century. By 2050, the share of renewable energy sources in final energy consumption is to be **increased to 60 per cent**, and primary energy consumption is to be cut by **50 per cent** compared to 2008.

The Climate Action Plan 2050 also specifies targets for the individual sectors for the first time. To cut greenhouse gas emissions by **at least 55 per cent** in all economic sectors by 2030 compared to 1990, target corridors for 2030 were agreed for the sectors.

2.1 International climate policy

The UNFCCC forms the basis for international climate diplomacy. Adopted in 1992, the goal of the treaty is to stabilise global greenhouse gas emissions at a level that prevents dangerous climate change. One hundred ninety-six countries and the EU – nearly all countries in the world – have ratified the UNFCCC. This means they have undertaken to report regularly on their greenhouse gas emissions and take climate action. Since 1995, conferences of the signatory states have taken place in various host countries – these have been referred to as UN Climate Change Conferences or Conferences of the Parties (COP).

The Kyoto Protocol, adopted in 1997, marked the first time that legally binding greenhouse gas reduction targets were agreed. In the first phase of the treaty, some industrialised nations – including all EU Member States – made a commitment to cut their greenhouse gas emissions by 2008. The continuation of the Kyoto Protocol in a second phase envisages that the participating industrialised countries will lower their emissions by an average of 18 per cent by 2020 compared to 1990 levels. For this same period, the EU committed to a 20 per cent cut in greenhouse emissions. Germany set itself a voluntary goal of reducing emissions by 40 per cent in this timeframe.

The Paris Agreement aims to limit global warming by the end of this century to well below 2°C and preferably to 1.5°C. It envisages achieving global greenhouse gas neutrality in the second half of this century. One hundred ninety-six countries have agreed on coordinated cooperation to combat global climate change. Whereas the Kyoto Protocol mainly applies to industrialised countries, the Paris Agreement represents the first time that a commitment has been made by all countries. All signatory states are required to set their own Nationally Determined Contributions (NDCs) to reducing greenhouse gases by 2020. Together with its Member States, the EU worked out an NDC that aims to cut EU-wide greenhouse gas emissions by at least 40 per cent by 2030 compared to 1990 levels. Germany therefore did not agree its own national contribution under the treaty, but has instead made a commitment to international climate action via the EU's contribution.

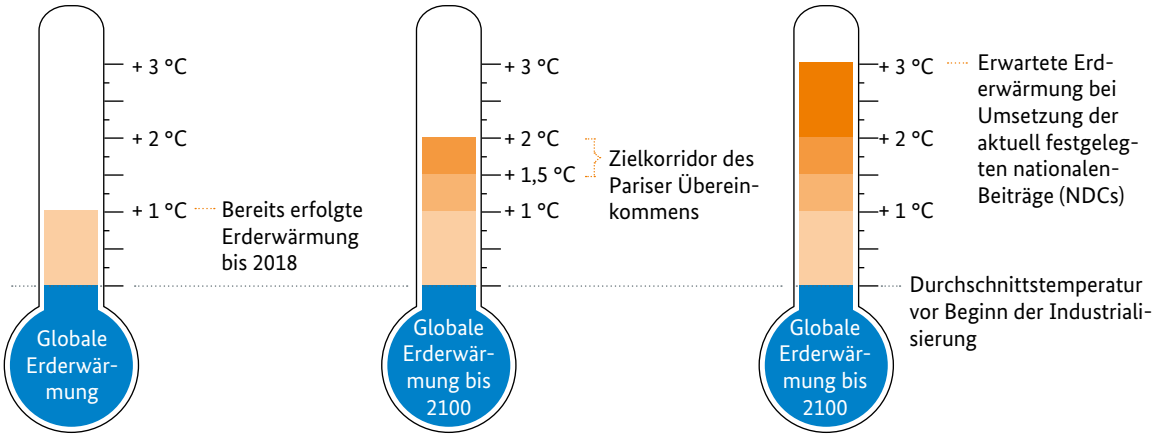
The fight against climate change will continue to require a coordinated approach by all countries. The 185 parties to ratify the Paris Agreement to date [8] have so far submitted 183 NDCs.[9] At present only seven countries have set climate targets in their NDCs that are compatible with the 2°C upper limit in the Paris Agreement.[10] If the parties stick with and implement their current commitments, global warming is expected to reach 3°C.[11] More climate action is therefore required to close the gap between the necessary emissions reductions and those currently planned (Figure 07). At the 24th Climate Change Conference in the Polish city of Katowice, the parties agreed a common rulebook on implementing the Paris Agreement, which is now binding on all countries for the first time. It particularly relates to international reporting on emissions and climate action. Under the Paris Agreement, new or revised NDCs are to be submitted in 2020. Apart from the international Climate Change Conferences, climate action is an important theme at the regular summits of the major industrialised and emerging powers. Nearly all the G20 countries recently reaffirmed their approach to tackling climate change under the German G20 presidency in 2017 and in Buenos Aires in 2018.

Climate finance plays a key role in implementing climate policy. As a responsible partner, Germany helps developing and emerging countries finance and implement climate action and climate change adaptation measures. In 2017, Germany made budget funding of around 3.65 billion euros available for international climate financing.[12] Since 2005, the Federal Government has increased its financial contribution to climate action and adaptation almost eightfold. Germany also makes additional contributions through public sector loans and by mobilising private funding. In 2017, the German development bank KfW together with the German investment corporation (Deutsche Investitions- und Entwicklungsgesellschaft) pledged 3.08 billion euros of financing from capital market funds. Germany's commitment contributes to the industrialised countries' goal of providing and

1.5°C

To reach the 1.5°C goal, global net CO_2 emissions have to fall to zero by around 2050.[13]

Abbildung 07: **Ambitionslücke zwischen Pariser Abkommen und aktuellen NDCs der Vertragsstaaten**



Quelle: Eigene Darstellung nach Navigant, New Climate Institute, Climate Analytics (2018)

mobilising 100 billion dollars annually from public and private sources for climate action and adaptation in developing countries from 2020 onwards. In addition, Germany is committed to implementing the long-term goal laid down in the Paris Agreement of directing global financial flows towards low-carbon and climate-resilient development.

> *"We need to do more, and we need more ambition." António Guterres, UN Secretary-General*

More than four fifths of climate finance flows into direct cooperation with developing and emerging countries, particularly via the Federal Ministry for Economic Cooperation and Development. Another important instrument is the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The IKI has supported climate action in developing and emerging countries since 2008. Almost 700 projects with a financing volume of 3.3 billion euros have been started since the initiative was launched. The IKI aims to stimulate specific reform and transformation processes in the partner countries and give impetus to international climate negotiations. One main focus is on helping the partner countries implement their NDCs. For example, there are projects that support solar roof installation in Mexico, sustainable mobility initiatives in major Indian cities and forest preservation in Pacific island states. The IKI also supports climate change adaptation projects such as innovative agricultural insurance products in Ghana.

Another portion of the financing for climate action is provided via multilateral organisations to facilitate comprehensive programmes in developing and emerging countries. The Federal Government pays contributions into international funds and facilities, such as the Green Climate Fund, the Adaptation Fund and the Global Environmental Facility for this purpose.

i

Climate change and migration

Migration has many causes, such as poverty, a lack of educational opportunities, political persecution and violent conflicts. Climate change is increasingly becoming another reason for migration. Heat, droughts, floods and other weather extremes affect food production, health and working conditions. Livelihoods that depend on climate-sensitive agriculture are especially at risk. People in developing countries have greater difficulty adjusting to the impacts of climate change when the necessary infrastructure and financial resources are lacking. Climate change exacerbates social inequalities, brings a risk of violent conflicts and leads to increased migration movements.

People are already leaving their homes because of climate change. In 2017, around 18 million people worldwide had to seek shelter from extreme weather events at another location within their own country.[14] By 2050, climate change could force more than 140 million people in sub-Saharan Africa, South Asia and Latin America to resettle inside their national borders.[15] Climate change will increase international migration pressure towards Europe, although exact numbers are hard to estimate. Global climate policy and adaptation measures will help to improve climate-dependent living conditions. Severely affected countries often need international financial assistance to deal with climate-related damage.

2.2 European climate policy

The EU pursues a common climate policy in consultation with its Member States. The EU is one of the driving forces in international climate negotiations. In its NDC, it has made a commitment to cut greenhouse gas emissions by at least 40 per cent by 2030 compared to 1990. To facilitate long-term planning and provide more reliable guidance for businesses and society, the European Commission unveiled its vision of "A Clean Planet for All" at the end of 2018, with a transition to greenhouse gas neutrality by 2050. By 2020, the EU and all other parties are asked to present a long-term climate strategy to implement the Paris Agreement.

> *"The aim of the EU should be to achieve climate neutrality by 2050. There is no way around it." Miguel Arias Cañete, European Commissioner for Climate Action and Energy*

The EU Emissions Trading System (EU ETS) is a key climate action instrument. It compels the energy sector, energy-intensive industry and, since 2012, aviation in the EU to pay to emit greenhouse gases. Companies are required to purchase tradeable emission allowances (also known as certificates or "carbon credits"). The volume of allowances available on the market is limited in line with the EU's long-term climate and energy goals. To make their contribution, sectors covered by the EU ETS have to cut their emissions by 43 per cent by 2030 compared to 2005. Since 2013, N_2O and PFCs have been included in emissions trading along with CO_2. In its original form, however, the EU ETS did not achieve the desired pricing effect. A growing surplus of emission allowances was due mainly to an overly generous initial issue of the carbon credits, the economic crisis and purchases of cheaper allowances from other countries. As a result, the price of EU emission allowances, and hence the incentive to reduce emissions, has been persistently low in recent years.

Reform of the EU ETS in February 2018 gave a boost to emissions trading in the EU. With the introduction of a Market Stability Reserve, surplus emission allowances

will gradually be transferred to a reserve from 2019 onwards. From 2023, the maximum volume of this reserve will be limited, with the result that any remaining allowances will be permanently removed from the market.

Making the freely available emission allowances more scarce should strengthen the price signal of emissions trading in the long term. Another reform element is the new possibility for Member States to cancel allowances in the event of additional national measures to shut down power generating capacities.

The announcement of the reform caused the price of EU emission allowances to triple from an average of 5 euros per tonne of CO_2 in 2017 to 15 euros in 2018.[16] At the beginning of 2019, the price for emission allowances stood at more than 25 euros per tonne of CO_2.[17] Because of the higher allowance prices, modern low-emission gas and steam power plants have in many cases become more competitive again since 2017 compared to hard coal power stations.[18]

i

Carbon pricing

Economic incentives are one way of reducing greenhouse gas emissions. Carbon pricing means market participants face additional costs depending on their greenhouse gas emissions. Pricing the emissions internalises the costs of harm, following the "emitter pays" principle. Despite the additional cost burden, businesses and governments increasingly support the principle of making businesses pay to emit greenhouse gases. There are two main instruments for pricing greenhouse gas emissions: emissions trading and carbon taxes.

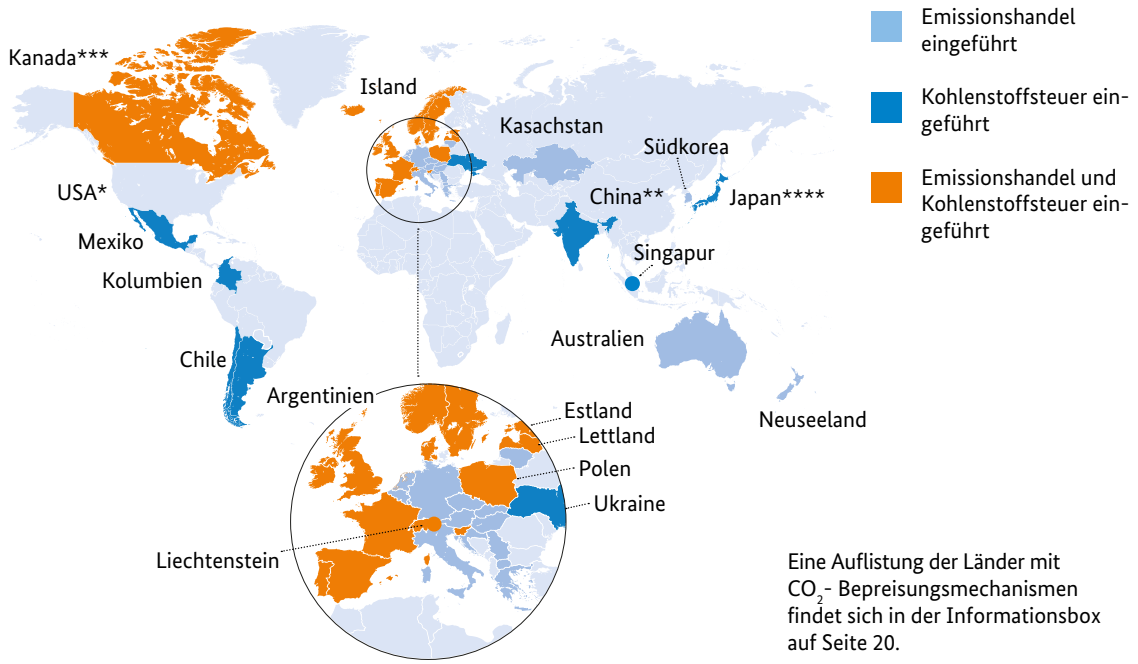
Emissions trading works on the "cap and trade" principle. Total volumes for emissions of particular greenhouse gases are limited (capped) and then issued in the form of allowances that can be traded.

Market participants who are subject to emissions trading have to possess an allowance for every tonne of greenhouse gas they emit. The price of an emission allowance is determined by the market. It varies depending on the supply of emission allowances and demand from market participants. Since emission allowances can be traded freely between market participants, emissions trading means that greenhouse gas emissions are avoided where the costs of doing so are lowest. The EU, Switzerland, Norway, Liechtenstein and New Zealand, as well as a number of regional administrations in China, the United States, Canada and Japan, have introduced emissions trading schemes.[19]

A carbon tax can be implemented as an alternative or in addition to emissions trading. Emissions of particular greenhouse gases are taxed at a fixed rate, often with an escalator mechanism. Unlike emissions trading, where the market influences the price, the price of emissions under a carbon tax is set by policymakers. The United Kingdom, Estonia, Latvia, Portugal, Slovenia, Spain, Ireland, France, Finland, Sweden, Denmark, Poland, Norway, Switzerland, Ukraine, Iceland, Liechtenstein, Colombia, Mexico, Chile, Japan, South Africa, Argentina and Singapore, as well as individual regional governments in Canada, have implemented a carbon tax.[20] Figure 08 provides an overview of carbon pricing mechanisms implemented globally. Various concepts for introducing a carbon tax are being discussed in Germany.

It is important to ensure equitable outcomes when pricing greenhouse emissions, as there may be significant movements in the prices paid by private individuals and businesses for electricity, petrol and other energy sources. For example, some of the tax revenues may be redistributed to taxpayers, as is the case in Switzerland.

Abbildung 08: **Weltweite Übersicht zu der Einführung von CO_2-Bepreisungsmechanismen**



Eine Auflistung der Länder mit CO_2- Bepreisungsmechanismen findet sich in der Informationsbox auf Seite 20.

* USA: Elf Bundestaaten (Kalifornien, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, Washington) haben Emissionshandelssysteme eingeführt.

** China: Sechs Provinzen (Chongqing, Fujian, Guangdong, Hubei, Shanghai, Tianjin) und die Städte Shenzhen und Peking haben Pilotprojekte für Emissionshandelssysteme eingeführt.

*** Kanada: Neben den CO_2-Bepreisungsmechanismen auf nationaler Ebene haben drei Bundesstaaten (Alberta, British Columbia, Neufundland und Labrador) Kohlenstoffsteuern und sechs Bundesstaaten (Alberta, British Columbia, Nova Scotia, Québec, Saskatchewan, Neufundland und Labrador) Emissionshandelssysteme eingeführt.

**** Japan: Tokyo und Saitama haben Emissionshandelssysteme eingeführt.

Quellen: ICAP (2019), Weltbank (2018b), BMU

More than half of tax revenues from EU emissions trading flow into climate action and energy efficiency measures. Around 90 per cent of emission allowances are allocated to Member States based on their emissions. Proceeds from auctioning the emission allowances are retained by the Member States.[21] The remaining portion of the emission allowances is allocated additionally to less prosperous Member States to reduce the CO_2 intensity of their economies and for climate adaptation. In 2018, emission allowances for around 173 million tonnes of CO_2 were auctioned in Germany, with a total value of 2.58 billion euros.[22] The Federal Government uses the proceeds to support climate action, such as the programmes and projects of the National Climate Initiative (NCI).

The EU's Effort Sharing Regulation (ESR) covers emissions outside the EU ETS. Greenhouse gas reduction goals by 2020 are set out in the Effort Sharing Decision. The ESR covers the subsequent period to 2030. It stipulates that greenhouse gas emissions in the buildings, transport, agriculture, smaller industrial plants, smaller energy producers and waste sectors have to be cut by at least 30 per cent by 2030 compared to 2005. Depending on their economic strength, the

Figure 09: **EU climate goals and policies**

EU climate package 2020

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

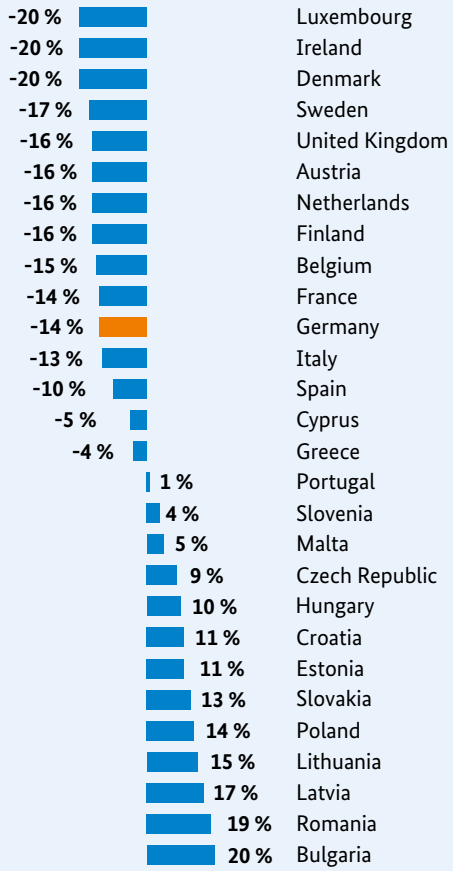
EU ETS
-21 % compared to 2005

Emissions trading for emission-intensive industrial plants and power stations in all Member States

Effort Sharing
-10 % compared to 2005

Reduction targets for all Member States based on economic output for non-ETS sectors, such as transport, buildings and agriculture

Distribution of the Effort Sharing goal among the 28 Member States (in % compared to 2005)



2030 climate and energy framework

40 % emissions reduction compared to 1990
(or -36 % compared to 2005)

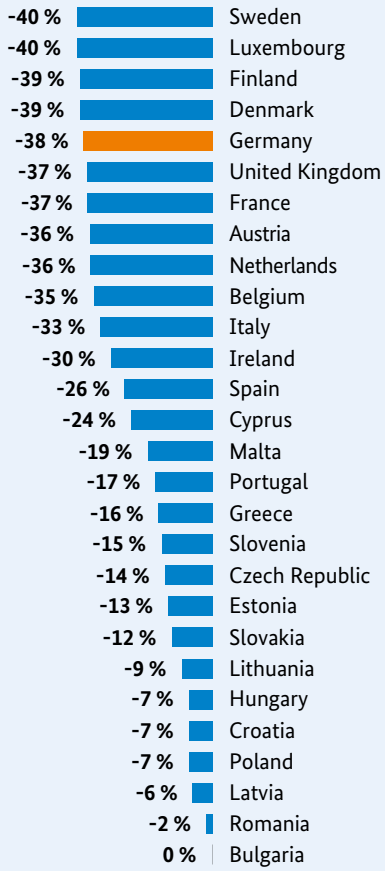
EU ETS
-43 % compared to 2005

Emissions trading for emission-intensive industrial plants and power stations in all Member States

Effort Sharing
-30 % compared to 2005

Reduction targets for all Member States based on economic output for non-ETS sectors, such as transport, buildings and agriculture

Distribution of the Effort Sharing goal among the 28 Member States (in % compared to 2005)



Source: European Commission (2018a)

Member States have different reduction targets ranging from 0 to 40 per cent. Germany has to cut its emissions by 38 per cent by 2030 compared to 2005 (Figure 09 shows the sharing of EU climate goals). If a Member State fails to reach its national reduction goals for 2020 and 2030, it has to buy emission allocations from other Member States that have surpassed their goals. This could be the case for Germany unless greenhouse gas reduction is accelerated in non-ETS sectors.

Energy efficiency and renewable energies are helping to cut greenhouse gas emissions across the EU. The long-term goal of reducing energy consumption is set out in the 2018 revision of the Energy Efficiency Directive. The target for 2030 is to achieve a 32.5 per cent efficiency improvement in primary energy consumption, compared to a baseline scenario with no efficiency improvements. Renewables' share in EU-wide final energy consumption should grow to at least 32 per cent by 2030. This target is binding at EU level and is defined in the 2018 revision of the Renewable Energy Directive. Implementation by Member States in the areas of renewable energy and energy efficiency is monitored in the energy union's governance system.

The European Climate Initiative (EUKI) of the BMU promotes knowledge and experience sharing in the EU. EUKI has an annual budget of 10 million euros for strengthening cross-border dialogue at various levels. The initiative aims to facilitate and speed up local implementation of the Paris Agreement. For example, EUKI creates networks between ambitious local authorities in Germany, Poland and other EU Member States. Another EUKI project introduces the topic of climate action to the curriculum in Bulgarian schools.

2.3 German climate policy

German climate policy follows international and European climate targets. In its Climate Action Plan, the Federal Government has set a long-term goal of reducing greenhouse gas emissions by 2050 in line with the Paris Agreement, with sector-specific reduction targets by 2030. Germany is aiming to be largely greenhouse gas neutral by 2050. By 2030, greenhouse gas emissions should be at least 55 per cent lower than in the comparison year 1990. By 2040, they should fall by at least 70 per cent. Within the EU's climate framework (ETS and non-ETS), Germany is required to achieve an overall reduction of around 53 per cent by 2030 compared to 1990. The national goal and the German contribution to the EU's targets are therefore nearly identical.

The Climate Action Plan 2050 splits the overall greenhouse gas reduction goal into sectors. Specific target corridors for emission reduction are defined for the energy, transport, buildings, agricultural and industry sectors by 2030. The Climate Action Plan also formulates strategic measures and milestones for each sector for 2030 and provides guidance for 2050. No reduction target is specified for the land use, land use change and forestry (LULUCF) sector, but it is to be maintained as a sink. The Climate Action Plan will be reviewed every five years to determine whether goals are being achieved. Interim goals and milestones will also be reviewed and adjusted if necessary. This will allow future technological developments and scientific findings to be taken into account. Proposals from all Federal Ministries are incorporated into the action programme to achieve the 2030 goals.

> *"We have to make climate policy more binding and ensure that all sectors fulfil their responsibilities." Svenja Schulze, Federal Minister for the Environment, Nature Conservation and Nuclear Safety*

Energy efficiency is a key pillar of emission reduction in Germany. Prioritising energy efficiency should encourage the exploitation of existing efficiency potentials while simultaneously bringing about a significant reduction in energy demand. With its 2010 Energy Concept, Germany set itself the goal of reducing primary energy consumption compared to the base

Figure 10: **Energy and climate goals of the Federal Government**

		Targets			
	Status quo*	**2020**	**2030**	**2040**	**2050**
Reduction in greenhouse gas emissions compared to 1990					
Total emissions	-30.6 % (2018)	At least -40 %	At least -55 %	At least -70 %	Largely green-house gas neutral
Energy	-33.4 % (2018)		-62 to -61 %		
Buildings	-44 % (2018)		-67 to -66 %		
Transport	-0.9 % (2018)		-42 to -40 %		
Industry	-30.7 % (2018)		-51 to -49 %		
Agriculture	-18.8 % (2018)		-34 to -31 %		
Other	-75 % (2018)		-87 %		
Renewable energy					
Share of gross final energy consumption	16.6 % (2018)	18 %	30 %	45 %	60 %
Share of gross electricity	37.8 % (2018)	At least 35 %	65 %* (At least 50 %)	At least 65 %**	At least 80 %**
Share of heat consumption	13.9 % (2018)	14 %			
Share in transport sector	5.6 % (2018)	10 %***			
Efficiency and consumption					
Primary energy consumption (compared to 2008)	-10.3 % (2018)	-20 %	→	→	-50 %
Final energy productivity (2008 to 2050)			2.1 % per year (2008 to 2050)		
Gross electricity consumption (compared to 2008)	-3.9 % (2018)	-10 %	→	→	-25 %
Primary energy demand for buildings (compared to 2008)	-18.3 % (2016)	→	→	→	-80 %
Heating demand for build-ings (compared to 2008)	-6.3 % (2016)	-20 %			
Final energy consumption for transport (compared to 2005)	-4.2 % (2016)	-10 %	-15 to -20 %	→	-40 %

* The Federal Government is aiming to increase the share of renewables in the electricity sector to around 65 per cent by 2030 in view of the challenges involved in achieving better synchronisation of renewable energies and grid capacities.

** Given that the increase in renewables' share in gross electricity consumption to 65 % by 2030 – as agreed in the coalition agreement – is currently the goal for 2040, the goals following 2030 will have to be adjusted accordingly.

Sources: own chart based on UBA (2019b), AGEB (2019a), AGEB (2019b), BMWi (2018a), AGEE-Stat (2019)

year 2008 by 20 per cent by 2020, and by 50 per cent by 2050. By 2018, primary energy consumption had been reduced by only 10.3 per cent compared to the base year 2008.[23] Supporting renewable energies is another important climate action instrument. The share of renewable energies in gross final energy consumption should rise to 30 per cent[24] and in gross electricity consumption to 65 per cent[25] by 2030. The interim goal for 2020 envisages a renewable share of 18 per cent, with a share of 15.6 per cent having already been achieved by 2017.

Numerous funding schemes are in place in Germany to support climate action. In the buildings sector, for example, KfW has a funding programme offering financial incentives for climate-friendly energy efficiency improvements, and the Federal Office for Economic Affairs and Export Control runs a market incentive scheme to promote the use of renewable energies for heating. Funding schemes operated by the Federal States complement these programmes, especially via regional bank grants.

The NCI supports projects for municipalities, businesses and consumers. These projects cover a broad spectrum of climate activities – from devising long-term strategies to providing concrete assistance and capital expenditure grants. The NCI supports municipal projects in various ways, such as by investing in more energy efficient street lighting. It also funds energy management, cycling infrastructure expansion and wastewater treatment plants in towns and municipalities. Since 2008, the BMU has supported more than 28,500 projects via the NCI. A funding volume of around 925 million euros has enabled total investments in excess of 3 billion euros. The NCI helps to establish climate action locally, puts climate action into practice and creates numerous models for others to follow. Investments funded by the NCI have saved and will continue to save a total of around 11 million tonnes of CO_2 equivalents over the life of the projects.

3. Emission trends and areas of action in the sectors

Summary

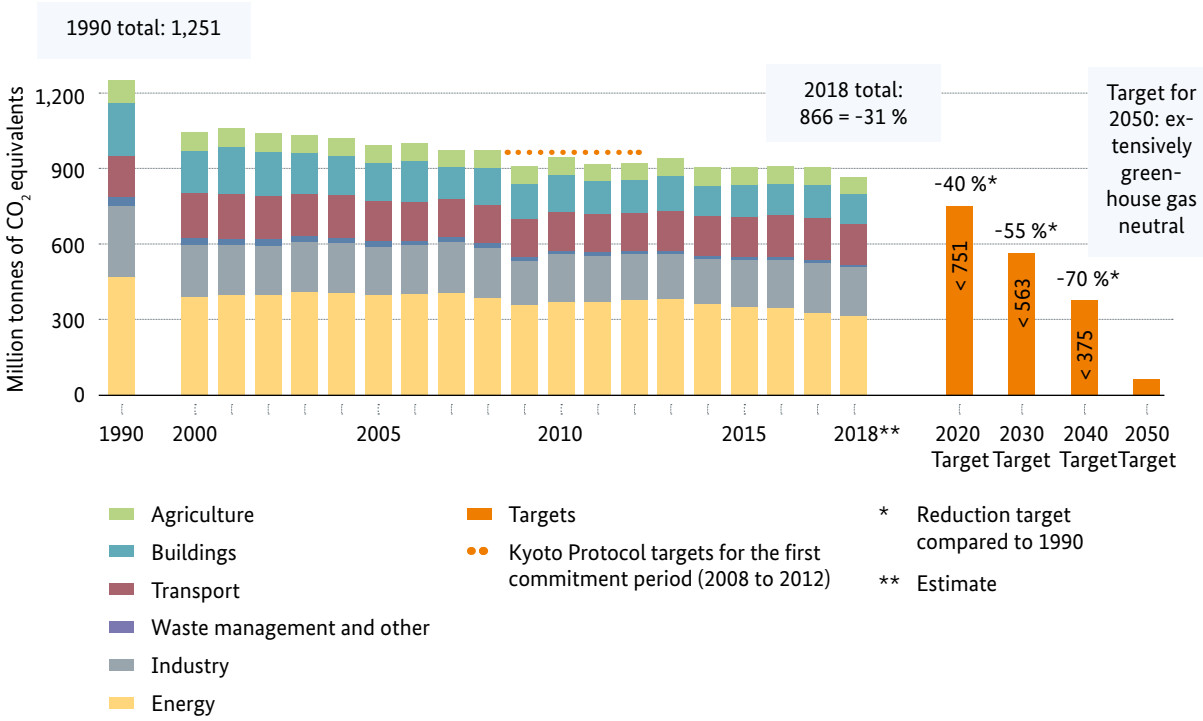
Germany's greenhouse gas emissions totalled **907 million tonnes of CO_2 equivalents** in 2017, a **reduction** of **27.5 per cent** compared to 1990 levels (estimate for 2018: 866 million tonnes and 30.8 per cent). At **35.8 per cent**, the **energy sector** accounted for the largest share of Germany's total emissions once again in 2017 (estimate for 2018: 35.9 per cent).

Direct greenhouse gas emissions from the **industry sector** – the second largest source – made up **22.1 per cent** of Germany's greenhouse gas emissions in 2017 (estimate for 2018: 22.7 per cent). The EU ETS covers the majority of greenhouse gas emissions from the energy and industry sectors. Together these account for around 50 per cent of total emissions. The **transport sector** was responsible for **18.4 per cent** of emissions in Germany in 2017 (estimate for 2018: 18.7 per cent).

The **buildings sector**, which includes private households as well as commerce, trade and services (CTS), accounted for **14.6 per cent** of greenhouse gas emissions in Germany (estimate for 2018: 13.6 per cent).

The largest fall in emissions since 1990 was recorded in **waste management**, at **73.5 per cent** (2017 and estimate for 2018: 1.1 per cent of greenhouse gas emissions). Agriculture accounted for **8.1 per cent** of German emissions in 2017 (estimate for 2018: 8.1 per cent). The **LULUCF** sector in Germany reduced its net emissions by **15.2 million tonnes of CO_2 equivalents** in 2017.

Figure 11: **Greenhouse gas emissions development in Germany by sector (excluding land use, land use change and forestry)**



Individual data points can be found in the table in the appendix on page 66.

Sources: UBA (2019b), UBA (2019c)

3.1 Emissions in Germany – past, present and future

From 1990 to 2017, greenhouse gas emissions in Germany fell by around 27.5 per cent (1990 to 2018: -30.8 per cent). According to initial estimates, total greenhouse gas emissions in Germany in 2018 amounted to around 865.6 million tonnes of CO_2 equivalents (Figure 11). This means that emissions fell by around 41 million tonnes of CO_2 equivalents compared to the previous year. In the reference year 1990, emissions stood at 1,251 million tonnes of CO_2 equivalents.

Climate policy measures at German and European level have played a decisive role in the fall in emissions. The economic upheaval in the Federal States of the former East Germany also led to a considerable decrease in emissions in the early 1990s. Economic changes, such as those following the 2009 financial crisis, and weather-induced fluctuations in heating demand have a significant influence on the emissions trend as well.

This brochure describes emissions according to their sector of origin (source principle). Energy, industry and transport were the three most emission-intensive sectors in 2017. Together they emitted 76.3 per cent of all greenhouse gases in Germany.

In 2018, greenhouse gas emissions in Germany fell again for the first time in several years. Mild weather was a main reason for the sharp drop in emissions. Other reasons were an increase in the amount of energy from renewables and a reduction in the use of fossil fuels.

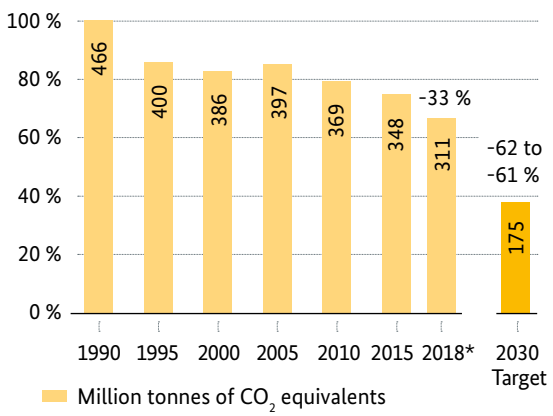
Better energy efficiency, higher oil and gas prices, lower population growth and slightly slower economic growth compared to previous years also played a part.[26]

The sharp decrease in greenhouse gas emissions in 2018 is due mainly to special circumstances specific to that year. This decrease is not indicative of a general trend.

By 2020, the reduction in greenhouse gas emissions is likely to reach only around 32 per cent.[27] Early in 2018, in the coalition agreement for the 19th legislative period, the coalition parties agreed to close the gap between existing climate action measures and emission reduction targets that existed with regard to the year 2020 (at least 40 per cent reduction compared to 1990) as quickly as possible.

The foreseeable failure to meet the target in 2020 has impacts on the subsequent period too. It makes achieving the goals for 2030 and 2050 more difficult, because the shortfall from the 2020 target (currently estimated at eight per cent) has to be made up as well as reaching the already ambitious targets for 2030 and 2050. It is therefore all the more important to secure a binding commitment to reach the goals for the 2030 time horizon.

Figure 12: **Emissions development in the energy sector**



* Estimate

Sources: UBA (2019b); UBA (2019c)

3.2 Energy sector

Emissions development

The energy sector generated the largest share – 35.8 per cent – of greenhouse gas emissions in Germany in 2017. Emissions came mainly from burning fossil fuels in public utility power plants to supply electricity and heat (Figure 13). Emissions from pipeline transportation of fossil fuels and diffuse emissions from fuels are also attributed to the energy sector. These occur, for example, when mine gas escapes from decommissioned mines.

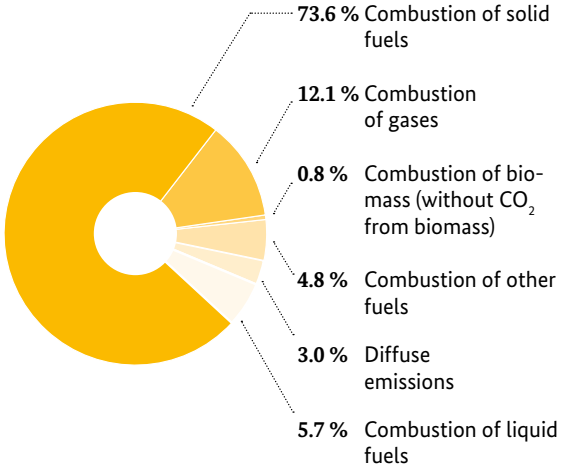
Based on the source principle, all emissions from public electricity and district heat production are attributed to the energy sector, even if the electricity or heat is used in the transport or buildings sector, for example. Reduced energy demand in other sectors, for example due to better energy efficiency, therefore has a positive impact on the energy sector too in the form of reduced energy demand. At the same time, increasing electrification would increase the demand for electricity and cause emissions in the energy sector to increase, assuming that fossil fuels are used to generate the electricity.

According to initial UBA estimates, total greenhouse gas emissions in 2018 from the energy sector came to around 310.5 million tonnes of CO_2 equivalents. This equates to a reduction of 33.4 per cent compared to 1990, and a drop of 4.3 per cent compared to the previous year (Figure 12). It is estimated that using renewable energies in the electricity sector prevented the emission of 184 million tonnes of CO_2 equivalents in 2018. Wind energy made the largest contribution, at close to 75 million tonnes.

The following factors are the main reasons for the sharp fall in greenhouse gas emissions from the energy sector in 2018. Fossil fuel use decreased because mild weather led to a lower demand for heat. High solar irradiation produced record solar power generation, and there was a further increase in power generated by wind turbines.

In addition, the higher price of EU emission allowances had an impact on power plant utilisation. In 2018, significantly less electricity was generated from hard coal than in previous years. Part of the reason for this is that hard coal power plants with an output of 1.5 gigawatts

Figure 13: **Emission sources in the energy sector in 2017 (without CO_2 from biomass)**



Source: UBA (2019b)

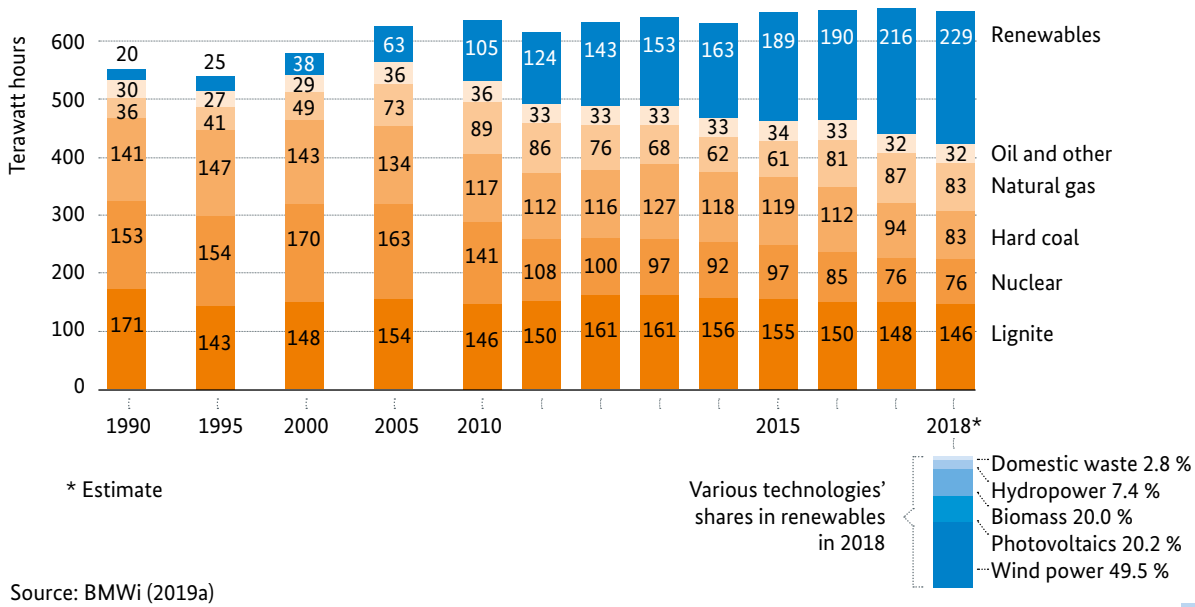
were transferred to the grid reserve. In addition some conventional hard coal power plants were forced to reduce their output in the summer because the water level in many rivers was not sufficient for the power plants' cooling requirements.

Figure 14 charts the trend in gross power generation in Germany since 1990. It clearly shows the strong growth of renewable energies in the electricity sector. According to provisional estimates by the Working Group on Energy Balances (Energy Balances Group), renewables accounted for 35.2 per cent of gross power generation in 2018.

Since the decision was taken in 2011 to phase out nuclear power, the percentage of electricity from these plants has decreased accordingly. Fossil-based power generation, on the other hand, has changed little in recent years in terms of its overall share, although coal-based electricity generation has fallen and natural gas-based production has risen. The share of electricity generated from lignite – the most emission-intensive form of power generation – fell by only 14.6 per cent between 1990 and 2018. Hard coal's share in gross power generation fell by 41.1 per cent over the same period, while gross power generation using natural gas more than doubled.

Moreover, the use of lignite and hard coal is responsible for the majority (2017: 73.6 per cent) of emissions in the energy sector, while its share of gross power generation in 2017 was just 37 per cent. This fact alone shows how important it is to gradually

Figure 14: **Development of gross power generation by energy source**



* Estimate

Source: BMWi (2019a)

reduce coal use for energy generation in Germany to achieve climate goals.

The other 26.4 per cent of greenhouse gas emissions in the energy sector in 2017 were attributable to using natural gas, oil and other fossil fuels (Figure 13). Their share in gross power generation in 2018 stood at 18.2 per cent (Figure 14).

Current political measures

The Federal Government aims for almost complete decarbonisation of the energy supply in Germany by 2050. Key action areas to achieve this goal are a progressive expansion of renewable energies in the electricity, heat and transport sectors; improving energy efficiency; and gradually moving away from fossil fuels. Action is therefore targeted at both energy provision and energy consumption.

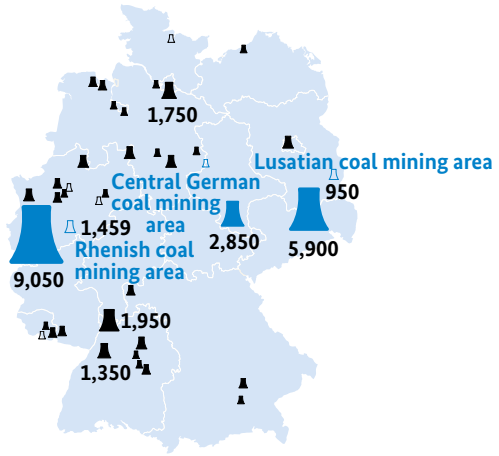
The Renewable Energy Sources Act (EEG) remains the basis for supporting renewable energies in Germany. In the past, EEG support strongly promoted the technological development of renewable energies, specifically wind and solar energy. At the same time, the costs of those technologies were brought down substantially. Even greater cost reductions were achieved by the introduction in 2017 of a competitive support scheme based on tenders for renewable energies. Today, renewable energies are in many cases the cheapest option for generating electricity.

In addition to the EEG's envisaged expansion of renewable energies, the package of energy reforms adopted in 2018 (known as the Energiesammelgesetz) introduces special tenders for onshore wind and solar energy. Each year until 2021, an additional four gigawatts each of solar and onshore wind power installations will be put out to tender. On top of that, the governing parties have resolved in their coalition agreement to increase the share of renewable energies in gross electricity consumption to 65 per cent by 2030.

62 – 61 %

The Climate Action Plan sets a target for the energy sector of at least a 62 to 61 per cent reduction in greenhouse gas emissions by 2030 compared to 1990.

Figure 15: **Currently installed capacities of lignite and hard coal power plants**



Lignite
Hard coal
Planned closure or put on security standby by 2020*

1,234 Total capacities of multiple power stations in megawatts

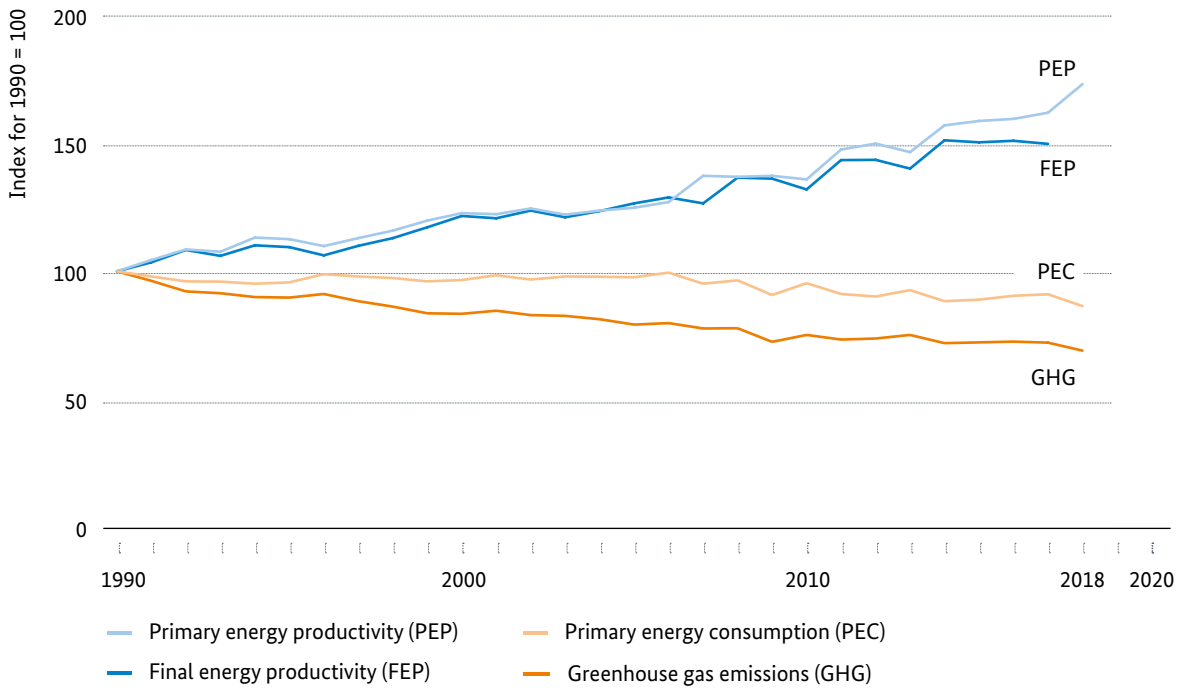
* Planned means the operators have told the Federal Network Agency that they want to close the plant

Sources: DIW, Wuppertal Institute, Ecologic (2018)

Renewable energies are also supported in the heat sector, such as via the market incentive scheme and tenders for innovative combined heat and power (CHP) systems (see Section 3.6).

Despite the progress already achieved, analysts[28] predict that renewables will need to expand more rapidly – especially wind and solar energy – and be better integrated into the energy system, to reach the targets that have been set (see Figure 10 in Section 2.3). Electricity networks will have to be further optimised and upgraded – including greater European integration – and incentives created for greater flexibility, especially with regard to demand. Sector coupling will have to be promoted too, and greater use of renewable energies will also be required in the heat sector, along with other low-emission heat sources such as waste heat.

Figure 16: **Decoupling of economic growth, greenhouse gas emissions and energy productivity**



Source: UBA (2019d)

Recent years have seen good overall progress in expanding renewable energies, although there has been only a limited reduction in coal-based electricity generation. Apart from an accelerated expansion of renewable energies, reaching the sectoral target for the energy sector by 2030 will require a systematic and incremental reduction in coal-based power generation over the coming years.

In June 2018, the Federal Government appointed the Commission on Growth, Structural Change and Employment (K-WSB). Its remit was to develop proposals for a gradual reduction and phasing out of coal-fired generation, and for sustainable and forward-looking structural development in the regions most affected by a coal phase-out. The commission was also tasked with presenting proposals for measures that would as far as possible close the gap to achieving the climate target for 2020. On 31 January 2019, the commission presented its findings to the Federal Government.[29]

Another key action area is boosting energy efficiency. Alongside cleaner electricity and heat generation, this is a way of reducing the overall energy demand. This is particularly important given increasing electrification in other sectors. Since energy savings begin with energy demand, the following Sections 3.3 to 3.6 discuss specific measures to increase energy efficiency.

Increasing energy efficiency also provides the basis for a more sustainable economy. Macroeconomic energy efficiency is measured in terms of energy productivity, meaning the ratio of gross domestic product (GDP) to energy consumption. Rising energy productivity in Germany (average annual growth rate from 1990 to 2015: 1.7 per cent) has led to a gradual decoupling of economic growth from energy consumption, and they are now following opposite trends.

Economic output (GDP) has risen by more than 50 per cent since 1990, while energy use has actually fallen during the same period. Energy productivity increased

i

Key recommendations for a gradual phase-out of coal-fired generation by the end of 2038

By 2022: around 12.7 gigawatts of lignite and hard coal power plants (nearly 5 gigawatts of lignite and 7.7 gigawatts of hard coal) should be decommissioned, leaving a total of around 30 gigawatts of coal-fired power plants on the grid at the end of 2022. (Figure 15 provides an overview of currently installed capacities of lignite and hard coal power plants.)

From 2023 to 2030: the capacity of coal-fired power plants on the market (without reserves) should be reduced to no more than 9 gigawatts of lignite and 8 gigawatts of hard coal. That means decommissioning a further 6 gigawatts of lignite and 7 gigawatts of hard coal compared to 2022.

Not later than the end of 2038: the remaining capacities should be decommissioned. In 2032, it should be checked whether the complete phase-out can be brought forward to 2035.

by more than 60 per cent between 1990 and 2017. The goal is to increase energy productivity by 2.1 per cent per annum based on final energy consumption (Figure 16).

3.3 Industry

Emissions development

The industry sector, after the energy sector, is the second-biggest source of greenhouse gas emissions in Germany. Direct greenhouse gas emissions from industry (emissions produced directly in industrial plants) accounted for a 22.1 per cent share of Germany's total greenhouse gas emissions in 2017. That equates to emissions of 200.1 million tonnes of CO_2 equivalents (Figure 17). Emissions from the industry sector are produced mainly in the energy-intensive segments and by electricity self-generation by industrial firms. Around 70 per cent of industrial greenhouse gases are attributable to the metal industry (such as iron and steel production), to manufacturing mineral products (such as cement) and to the chemical industry (producing basic chemicals). At the same time, these industrial emissions have different causes. Around two thirds of industrial emissions result from energy provision in industry (industrial furnaces). The other third of emissions are process-related and are generated by production processes (Figure 18). Process-related greenhouse gas emissions include the non-energetic use of carbon-based fuels and raw materials, and the process-related release of greenhouse gases other than CO_2.

In addition to direct greenhouse gas emissions, industry also produces indirect emissions by sourcing third-party electricity and district heating. Together with the energy produced and consumed by the industry sector, this results in the final energy consumption breakdown shown in Figure 19. The indirect emissions are reported in the energy sector. Improving energy efficiency in the industry sector therefore also has a positive effect on the emissions footprint of the energy industry.

Between 1990 and 2017, greenhouse gas emissions from industry fell by 29.4 per cent. While emissions fell continuously until 2002, no clear reduction trend has been evident since then.

Because of the robust economy, industrial greenhouse gas emissions actually rose again in 2017, for the third year in a row. It is estimated that greenhouse gas emissions fell in 2018 by 1.8 per cent to 196 million tonnes of CO_2 equivalents.

51 – 49 %

The Climate Action Plan sets a target for the industry sector of at least a 51 to 49 per cent reduction in greenhouse gas emissions by 2030 compared to 1990.

Current political measures

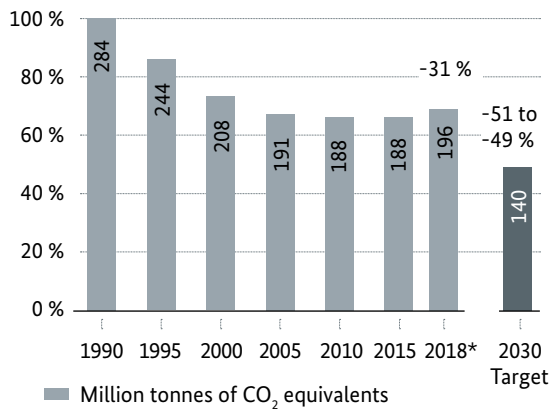
Apart from tapping energy efficiency potentials and integrating renewable heat, it is clear that a complete changeover of processes to climate-neutral alternatives is also required, together with material and resource efficiency. These are the key action areas to achieve extensive decarbonisation of the sector.

Various support schemes exist to stimulate investment in energy efficiency technologies and promote the increased use of renewable energies. In future, there will be a greater focus on combined support for energy efficiency and process heat from renewables. A central support programme for industrial enterprises was set up in January 2019. This investment programme combines previous support schemes for cross-sectional technologies, production processes, energy management systems, waste heat usage and renewable heat. STEP up! is a recently improved competitive energy efficiency support programme that complements the industrial funding landscape. There are also many other support measures, such as support for cogeneration in the Combined Heat and Power Act (KWKG), research funding and energy efficiency networks.

As well as efficiency improvements and using renewable energies, as mentioned above, extensive decarbonisation of the industry sector with a 2050 time horizon will require process-related emissions to be cut to a minimum. Particular challenges arise in the production of steel, cement, lime and non-ferrous metals, and in parts of the basic chemicals sector. Process-related emissions can only be reduced by switching to new, low-emission production processes. A majority of process-related emissions could be avoided if new production methods were implemented, which would mean a complete change in technical processes. For example, instead of producing steel via a reaction with coking coal, using fossil fuels to fire a furnace, it could be produced through the direct reduction of iron ore with hydrogen.

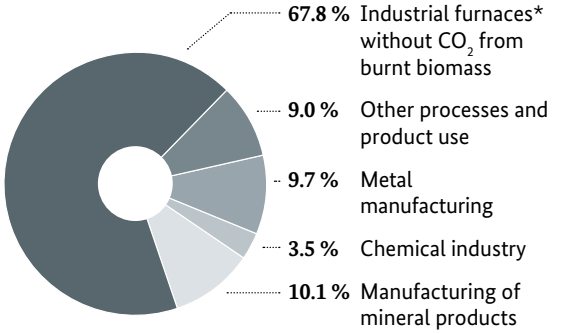
Industry has an interest in innovative production methods. However, some of these methods are not yet market-ready, and for the time being – like many innovations – they are more expensive than existing emission-intensive technologies. State support is therefore needed to realise the necessary investments in springboard innovations – from research and development to testing, market launch and operation. With this in

Figure 17: **Emissions development in the industry sector**



Sources: UBA (2019b), UBA (2019c) * Estimate

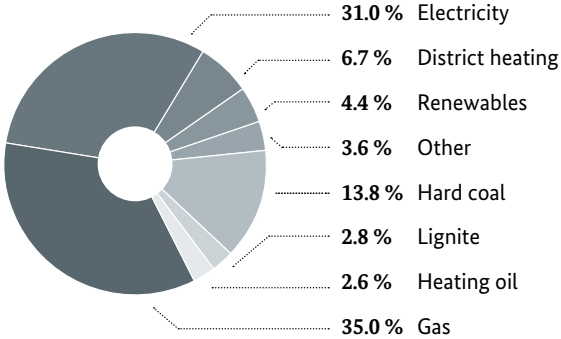
Figure 18: **Emission sources in the industry sector in 2017**



24.8 % of industrial emissions are process-related.
*Combustion processes, for example from firing rotary kilns

Source: UBA (2019b)

Figure 19: **Final energy consumption in the industry sector in 2017**



Source: BMWi (2019a)

i

Material efficiency and substitution in industry

One key element of climate action in industry is a high-efficiency strategy to cut resource and energy requirements in production. Resource efficiency consists of cost and energy efficiency plus a third aspect: material efficiency. Material efficiency is defined as the relationship between the benefit (manufactured products) and cost (materials used).

Specifically, an increase in material efficiency and substitution can achieve emission reduction potentials in industrial production processes that had not previously been realised, and therefore make an important contribution to climate action. If emission-intensive basic materials are used more efficiently along the value chain, the sometimes considerable greenhouse gas emissions resulting from their mining, transportation, preparation or use can be reduced in production.

That also applies to basic materials that are incorporated into products and goods, as well as their disposal and the recycling of raw materials. Better recycling can be achieved by strengthening the principle of the circular economy. Another way to boost raw material and material efficiency – and hence reduce emissions – is to integrate material flows across sectors: slag from iron and metal production can be incorporated into construction materials, for example. Moreover, innovations in materials science can replace high-emission materials.

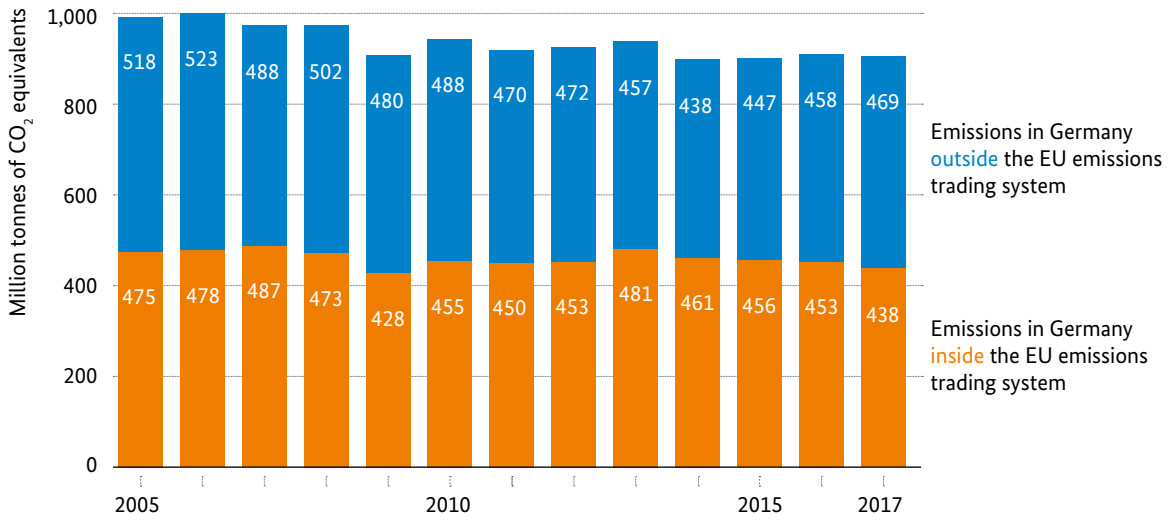
The Federal Government targets a continuous increase in material and resource efficiency. Relevant indicators and measures are set out in the regularly updated national resource efficiency programme (currently: ProgRess II).

mind, the Federal Government plans to create a scheme to support decarbonisation in industry. In the Lusatia region, a centre of competence in energy-intensive industry is being set up.

Energy and climate policy measures also take the competitiveness of energy-intensive industry into account. The EU ETS covers roughly half of German emissions (Figure 20). Industrial enterprises that are covered by emissions trading must report on their greenhouse gas emissions and buy and use corresponding allowances. Companies that are particularly exposed to international competition receive an allocation of allowances free of charge for a transitional period.

Energy-intensive industry also benefits from statutory exceptions that limit the costs firms incur due to high energy consumption, regardless of whether they are part of the ETS. They receive reductions or compensation for government-imposed price components (EEG levy and CHP levy, energy and electricity taxes, grid charges). That is intended to ensure Germany's attractiveness as a production location and prevent carbon leakage, meaning the transfer of production and emissions overseas.

Figure 20: **Emissions development inside and outside the EU Emissions Trading System**



Emissions values in emissions trading between 2005 and 2012 do not fall within the current emissions trading framework.

Sources: UBA (2019b), EEA (2018)

3.4 Waste and recycling management

Emissions development

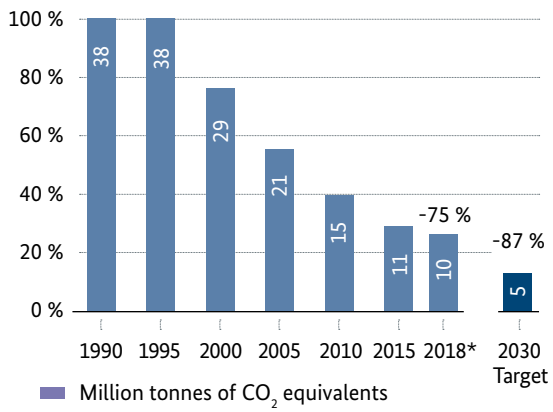
The waste and recycling management sector accounts for a small percentage of total climate-relevant emissions in Germany. In 2017, the figure was 1.1 per cent. In 2017, 10.2 million tonnes of CO_2 equivalents were emitted in the sector. The estimated total for 2018 is 9.6 million tonnes of CO_2 equivalents (Figure 21). That includes emissions from wastewater treatment. In 2017, as in previous years, nearly 90 per cent of the sector's total emissions were landfill gases or attributable to wastewater management (Figure 22).

Since the beginning of the 1990s, this sector's emissions have fallen by an above-average 73.5 per cent. This is due mainly to the reduction in CH_4 emissions as a result of the 2005 ban on sending untreated biodegradable municipal waste to landfill. Further savings have been achieved by using waste as a material and for energy, and through increased recycling – particularly glass, paper and cardboard, but also metal and plastics. These are counted as credits in national climate reporting, where they amount to significant reliefs or savings on climate-relevant emissions and fossil fuels. The savings, however, are credited to the industry or energy sector.

Current political measures

Building on what has been achieved by the systematic environmental policy of recent years, there are numerous efforts at national and European level to continue to promote climate action in the areas of recycling management and resource conservation. The importance of better recycling management and resource conservation will increase sharply in other sectors such as construction and industry in coming decades.

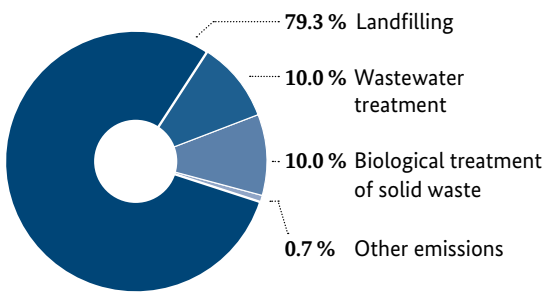
Figure 21: **Emissions development in waste management and other****



* Estimate
** Without credits from recycling and energy generation

Sources: UBA (2019b), UBA (2019c)

Figure 22: **Emission sources in waste management in 2017 (excluding CO_2 from biomass)**



Source: BMWi (2019b)

The biggest residual technological potential in waste management consists in more widespread aeration and degasification of old landfill sites. The BMU is making increased funding available for this and other emission reduction measures (in wastewater treatment) via the new municipal policy in the NCI.

Furthermore, increased use of bioenergy from biodegradable waste and other biogenic waste materials can help to mitigate climate change. Although this would not result in direct emission reductions in the waste sector, this bioenergy (together with other waste products like slurry) could be used instead of fossil energy.[30]

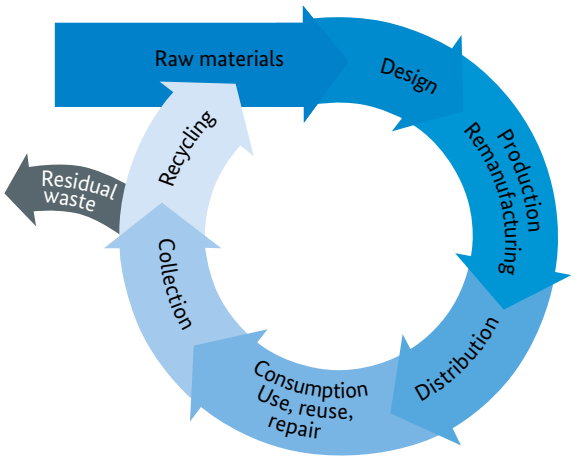
In addition to the residual possibilities for technical improvements, waste avoidance represents a considerable lever for reducing greenhouse gas emissions. However, this sector can only influence this potential to a limited extent. Efforts are currently under way at national and European level to avoid waste and develop the circular economy.

The Packaging Act came into force in Germany in January 2019. In particular, it envisages higher rates of recycling for plastic packaging. The material recycling rate is to increase from 36 per cent currently to 63 per cent by 2022. The recycling rate for metals is to increase from 60 to 70 per cent currently to 90 per cent, for glass from 75 per cent currently to 90 per cent, and for paper from 85 to 90 per cent. In addition, a new national authority, the Zentrale Stelle Verpackungsregister, has been created. It is tasked with setting up and administrating a packaging register called LUCID, with the aim of improving transparency and control in the use and disposal of packaging.

The Packaging Act is part of an overall strategy to avoid waste and improve recycling management. Alongside the Circular Economy Act from 2012, this strategy also includes the five-point plan for less plastic that the BMU presented in November 2018 and the parallel campaign “No to the Throwaway Society”. It identifies five main points for moving away from the throwaway society. Unnecessary plastic waste should be avoided where possible by not using plastic packaging. Packaging design should also be more environmentally friendly to facilitate recycling. The use of microplastics in cosmetics should stop by 2022. In addition, the Federal Government will make a financial contribution to help control marine litter.

The EU also wishes to further strengthen the circular economy and resource conservation (Figure 23). In addition to the Action Plan for the Circular Economy, it adopted further measures in 2018. The Strategy for Plastics in a Circular Economy consists of a package of measures to recycle all plastic waste in the EU by 2030. The EU is also examining how to establish a stronger circular economy for the 27 most critical raw materials used in the EU, and how to better coordinate

Figure 23: **Circular economy concept**



Source: European Commission (2014)

legislation relating to chemicals, product design and waste management. One example of this is the continuous improvement of product standards under the EU's Ecodesign Directive.

3.5 Transport

Emissions development

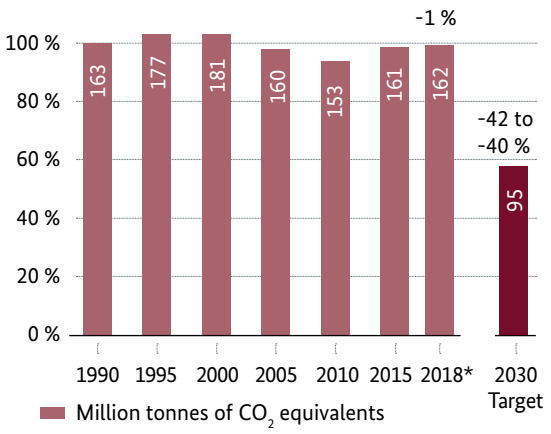
The trend for rising greenhouse gas emissions in the transport sector continued in 2017, with 167 million tonnes of CO_2 equivalents (Figure 24). At 167 million tonnes of CO_2 equivalents, emissions are higher than in the reference year 1990. The transport sector remains the third-largest source of greenhouse gas emissions in Germany, with a share of 18.4 per cent. According to UBA estimates, emissions in the transport sector fell slightly in 2018 by 3 per cent to 162 million tonnes of CO_2 equivalents. One explanation could be that the price of petrol went up by 7 per cent and diesel 12 per cent compared to the previous year. The main reasons for continuing high greenhouse gas emissions in the transport sector are an increase in vehicle kilometres and person / freight tonne kilometres travelled, the dominance of fossil fuels and continuing high average CO_2 emissions from cars.

With a share of 96 per cent, the vast majority of emissions are caused by road traffic, of which 61 per cent are due to cars. The other four per cent occur in national aviation, shipping and rail transport (Figures 25 and 26). International aviation and shipping are not counted when calculating greenhouse gas emissions from the transport sector. Emissions from electricity consumption in the transport sector are also not shown here. Instead they are allocated to the energy sector based on the source principle.

Both freight traffic and passenger traffic (measured in freight tonne kilometres and person kilometres) are continuously increasing: passenger traffic increased by 38 per cent between 1991 and 2016 (to 1,251 billion person kilometres in 2015).[31] In the same period, passenger vehicle kilometres travelled increased by 31 per cent, and freight vehicle kilometres travelled by 71 per cent.

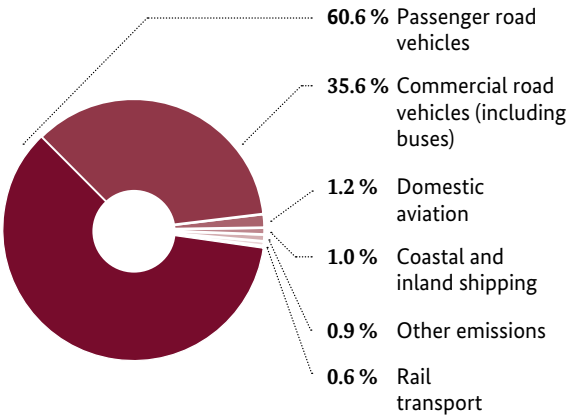
Greenhouse gas emissions from cars depend both on the drive technology and fuel used, and on the efficiency of the vehicle. Average specific CO_2 emissions of annually newly registered cars in Germany in 2017 stood at 127.1 grams CO_2 per kilometre.[32] It should be noted that this value was calculated using the New European Driving Cycle (NEDC) method, which was replaced in 2018 by the Worldwide Harmonized Light

Figure 24: **Emissions development in the transport sector**



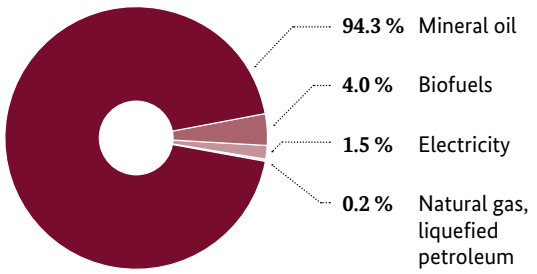
Sources: UBA (2019b), UBA (2019c) * Estimate

Figure 25: **Emission sources in the transport sector in 2017 (excluding CO_2 from biofuels)**



Source: UBA (2019b)

Figure 26: **Final energy consumption in the transport sector in 2017**



Source: BMWi (2019a)

Vehicles Test Procedure (WLTP). Accordingly, actual CO_2 emissions were higher. Within the EU, Germany has the second-highest average CO_2 emissions for new cars (Figure 29). Specific CO_2 emissions of the car fleet have fallen by 14.7 per cent since 1995.[33] Significantly larger reductions would have been possible, however, if improvements in energy efficiency had not been offset by the trend towards larger, heavier and higher-performance cars. Considerably greater decreases in air pollutants such as particulate matter, nitrogen oxides, volatile organic compounds and sulphur dioxide were achieved over the same period.

The switch from fossil fuels to low-emission drive technologies is gradually gaining momentum. Alternative drive technologies had a high growth rate of 54.3 per cent in 2018, which was even higher than the previous year (Figure 27).[34] Petrol and diesel are still the main propulsion systems, however, accounting for 94.7 per cent of new registrations. For electromobility to achieve significant emission savings in the overall picture, the electricity mix should ideally be greenhouse gas neutral. But even with today's electricity mix, battery electric vehicles are 27 per cent less emission intensive than cars fuelled with petrol.[35]

Biofuels also reduce Germany's overall emissions. In 2017, 7.7 million tonnes of CO_2 equivalents were saved by using biofuels.[36] It should be noted here, however, that only the direct emissions associated with biofuel use are counted in the calculated savings. These occur in connection with farming, production and transportation, for example. Particularly in the case of conventional biofuels from cultivated biomass, indirect land use change impacts can in some cases result in the emissions being significantly higher than with fossil fuels.

Current political measures

Policy action areas in the transport sector include improving the energy efficiency of all modes of transport, switching to low-emission drive systems and fuels, and shifting traffic to low-emission modes of transport such as local public transport, walking and cycling, as well as new mobility concepts like car sharing and ride sharing.

Figure 27: **New cars registered in the last ten years by selected fuel types in Germany**

	Petrol	Diesel	Liquid petroleum gas (LPG)*	Natural gas (CNG)*	Electric	Hybrid	Total
2008	1,695,972	1,361,457	14,175	11,896	36	6,464	3,090,040
2010	1,669,927	1,221,938	8,154	4,982	541	10,661	2,916,260
2012	1,555,241	1,486,119	11,465	5,215	3,364	21,030	3,082,504
2014	1,533,726	1,452,565	6,234	8,194	13,049	22,908	3,036,773
2016	1,746,308	1,539,596	2,990	3,240	25,154	34,252	3,351,607
2018	2,142,700	1,111,130	4,663	10,804	67,504	98,816	3,435,778
2018: growth compared to 2017 in %	7.9 %	-16.9 %	6.0 %	190.2 %	23.9 %	78.9 %	-0.2 %

Source: KBA (2018)

* Including bivalent engines

In September 2018, the Federal Government set up the National Platform Future of Mobility. The platform's Working Group 1 is tasked with identifying suitable measures in the transport sector to achieve the Federal Government's transport sector climate goals for 2030 (reduction by 42 to 40 per cent compared to 1990). The group presented its interim report to the Federal Government in March 2018.

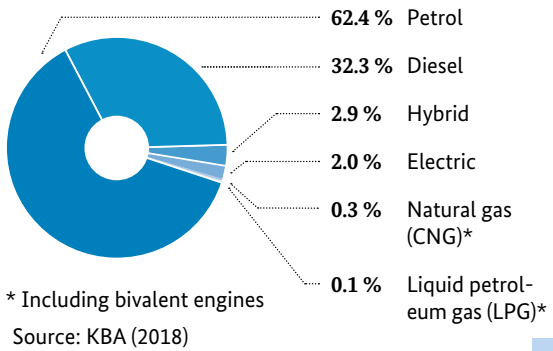
Since 2009, fleet targets have applied to car makers in the EU for average greenhouse gas emissions from all newly registered vehicles. In 2017, the average value in the EU was 118.5 grams of CO_2 per kilometre. By 2021, the average value must decrease to 95 grams of CO_2 per kilometre. A limit of 147 grams of CO_2 per kilometre by 2021 applies to light vans.

In December 2018, the European Council and European Parliament agreed limits for cars and light vans for the period 2021 to 2030. The European Parliament approved the draft legislation in March 2019. It is still awaiting final approval by the Council of Ministers.

42 – 40 %

The target for the transport sector is at least a 42 to 40 per cent reduction in greenhouse gas emissions by 2030 compared to 1990.

Figure 28: **Share of new car registrations in 2018**



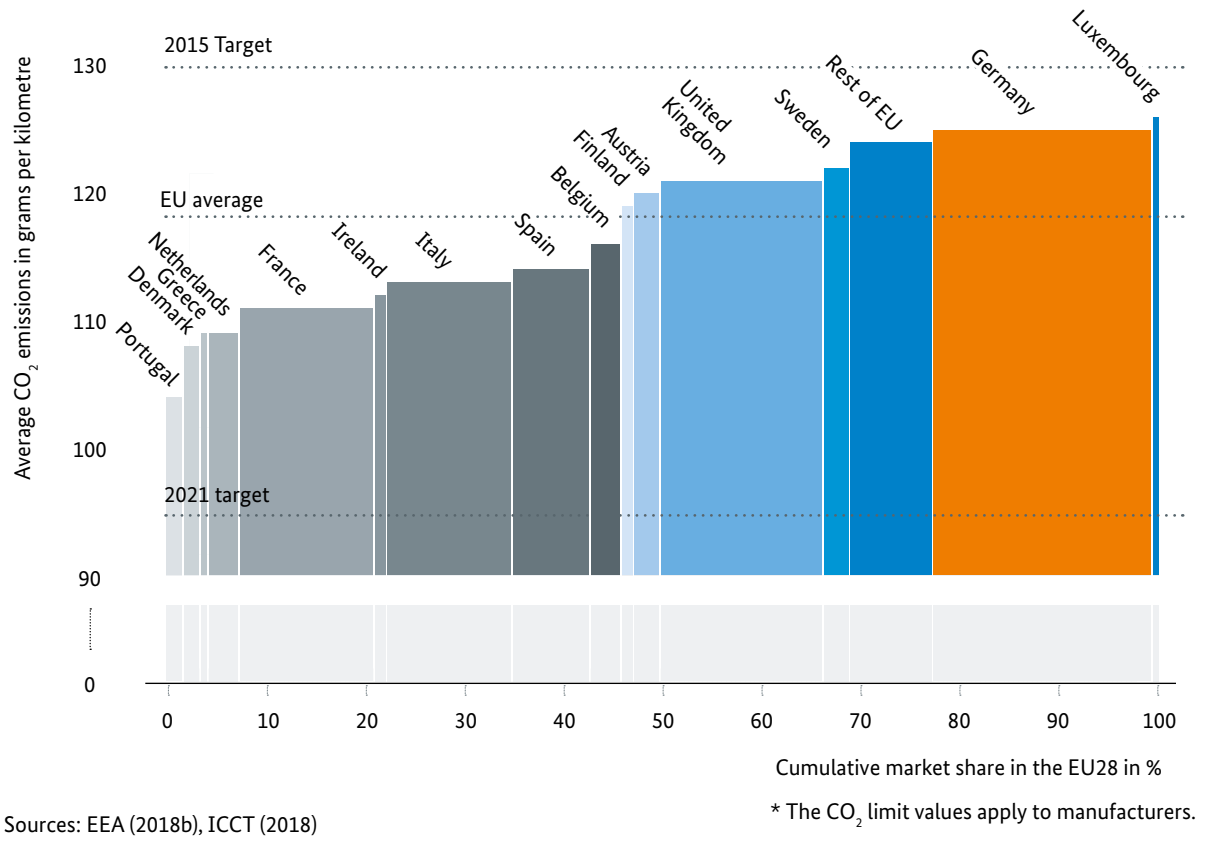
* Including bivalent engines

Source: KBA (2018)

Accordingly, CO_2 emissions from newly registered cars should be reduced by a further 37.5 per cent by 2030 compared to 2021.

As an interim target, EU-wide CO_2 emissions from new cars are to be cut by 15 per cent by 2025 compared to 2021. For light vans, the target is to reduce average emissions from newly registered vehicles by 31 per cent by 2030 compared to 2021. Furthermore, emission limits will be introduced for the first time for newly registered heavy-duty vehicles between 2021 and 2030. Manufacturers who fail to meet the targets will face fines. To enable realistic measurements of emissions from new cars, the NEDC test

Figure 29: **Average CO_2 emissions of passenger cars by EU Member State in 2017 and CO_2 limits for newly registered passenger cars* in the European Union (NEDC)**



Sources: EEA (2018b), ICCT (2018)

* The CO_2 limit values apply to manufacturers.

method was replaced in 2017 by the WLTP developed by the United Nations.

Germany is promoting the expansion of charging infrastructure for electromobility. In December 2018, around 16,100 public charging points were available in Germany for electric car users.[37] Of this total, 12 per cent were fast charging points with a charging power of at least 50 kilowatts. The coalition agreement envisages installing 100,000 more charging points by 2020 (see Section 4.3).

The Biofuel Sustainability Ordinance aims to guarantee the environmental compatibility of biofuels. The ordinance states that biofuels are only deemed to be sustainable if they save at least 50 per cent on greenhouse gases compared to fossil fuels, and that areas of land with a high carbon content or high biodiversity may not be used to cultivate the plants used for biofuel production.

The coalition agreement of March 2018 sets out several goals to promote rail transport in Germany and make it more environmentally friendly. Passenger numbers should be doubled by 2030, and electrification of the track network increased from 60 to 70 per cent by 2025.

3.6 Buildings

Emissions development

In 2017 14.6 per cent of greenhouse gas emissions in Germany occurred in the buildings sector. This sector comprises private households as well as the CTS segment. Almost all emissions in the buildings sector are caused by burning fossil fuels – primarily gas – to heat rooms and hot water (Figures 31 and 32).

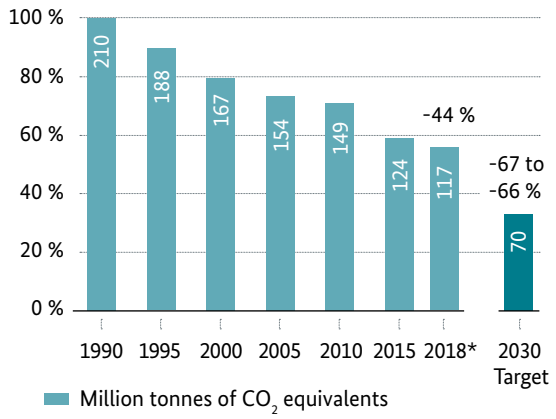
Following the source principle, emissions arising when the buildings sector is supplied with electricity and heat by public utility companies (as in the case of district heat, for example) are attributed to the energy sector and designated as indirect emissions. If the indirect emissions in the energy sector that arise from supplying electricity and heat to the buildings sector are also taken into account with the direct emissions from the buildings sector, then the building sector's share of total emissions is roughly twice as high, accounting for almost one third of emissions in Germany.

Between 1990 and 2017, greenhouse gas emissions in the buildings sector fell by 37.1 per cent. In 2017, emissions from the buildings sector stood at 132 million tonnes of CO_2 equivalents. According to initial UBA estimates, the figure for 2018 came to 117 million tonnes of CO_2 equivalents. A particularly sharp drop (-46 per cent) occurred in the CTS sector between 1990 and 2005. Between 2005 and 2017, emissions in the CTS sector fell only slightly and are currently at around 50 per cent of 1990 levels. Greenhouse gas emissions from private households fell by 29.6 per cent from 1990 to 2017.

Weather conditions have a significant influence on overall emissions, as room heating is responsible for roughly two thirds of greenhouse gas emissions in the buildings sector. For example, the warm weather in 2014 was partially responsible for the remarkable fall in emissions by 20.7 million tonnes of CO_2 equivalents compared to the previous year. From 2014 to 2017, greenhouse gas emissions in the buildings sector rose again by 12.9 million tonnes of CO_2 equivalents.

Two thirds of residential buildings in Germany were constructed before the first Thermal Insulation Ordinance of 1979. They require far more energy than structures built subsequently. Figure 33 shows the

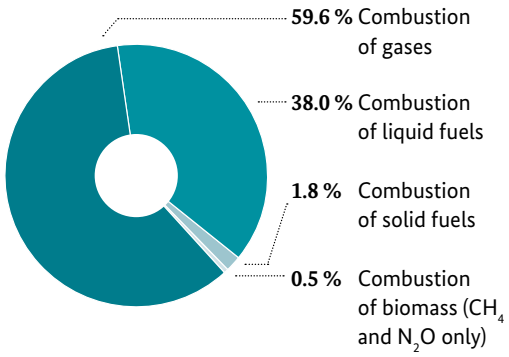
Figure 30: **Emissions development in the buildings sector**



* Estimate

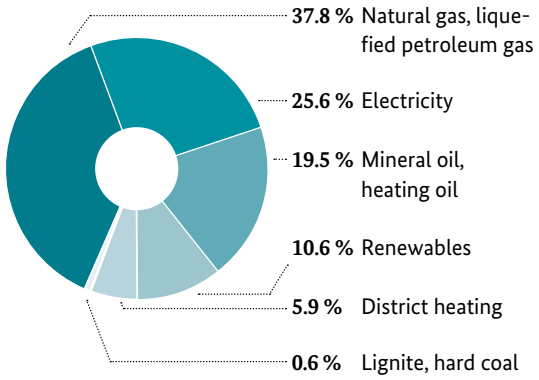
Sources: UBA (2019b), UBA (2019c)

Figure 31: **Emission sources in the buildings sector in 2017 (without CO_2 from biomass)**



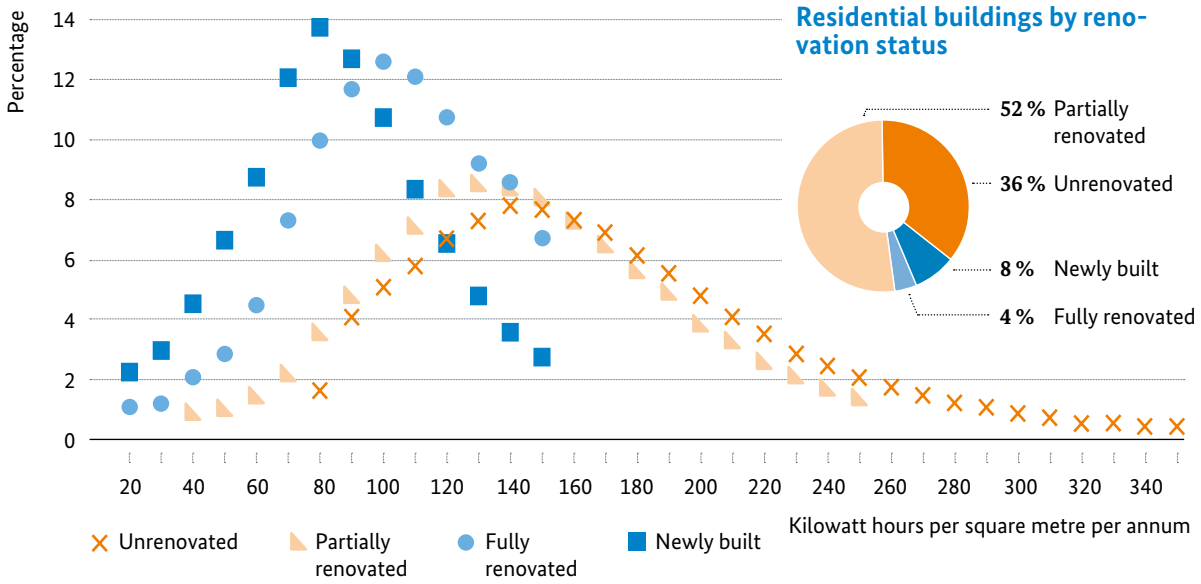
Source: UBA (2019b)

Figure 32: **Final energy consumption in the buildings sector in 2017**



Source: BMWi (2019a)

Figure 33: **Distribution of weather-adjusted heating energy consumption by renovation status**



Source: UBA (2019e)

distribution curves of heating energy consumption for different categories of building based on their renovation status, and their share in the total stock of buildings. It clearly shows the high degree to which heating energy consumption is affected by energy efficiency improvements. A very large percentage of the building stock still has significant potential to reduce energy consumption through efficiency measures. With substantial efficiency improvements (such as installing loft insulation, fitting energy efficient windows and eliminating thermal bridges) and by integrating renewable energies into the heating system (such as through solar thermal or environmental heat), energy consumption and greenhouse gas emissions could be reduced considerably.

Current political measures

The Federal Government wants Germany's building stock to become nearly climate-neutral by 2050. The Energy Efficiency Strategy for Buildings shows that this goal is achievable with a combination of energy efficiency and renewable energies. Improving energy efficiency is particularly important, as it enables the use of efficient, renewable heating technologies (such as heat pumps) and can effectively and permanently cut demand for scarce energy resources for heating buildings. Energy efficiency advances in the buildings sector may also ease competition with other sectors for limited resources (such as biomass).

At the same time, there are currently insufficient economic incentives or suitable regulations that would promote the transition to a climate-neutral building stock quickly enough. The 2017 forecast report indicates that from the current vantage point, the measures implemented and planned to date are not sufficient to achieve the target set for the buildings sector. For 2030, the report predicts that even with the implementation of the ambitious climate mitigation measures in the National Action Plan on Energy Efficiency (NAPE),

there remains a gap to achieving the sector's target of up to 20.5 million tonnes of CO_2 equivalents. Additional measures are therefore needed.

Along with the progressive revision of standards for new buildings, energy efficiency improvements in existing buildings are essential to reaching the sectoral targets. Buildings only very rarely undergo a full energy efficiency refurbishment. In most cases, existing buildings are upgraded in stages. It therefore makes sense to focus more on this area. To make planning and implementation easier for owners, a new instrument called the individual refurbishment roadmap for residential buildings has been available since 2017. As a software-assisted tool, it offers a transparent, tailored overview of long-term refurbishment steps for buildings.

Another measure is the planned Building Energy Act. It aims to harmonise and simplify the existing rules – the Energy Saving Act, Energy Saving Ordinance and Renewable Energies Heat Act. Measures in the Building Energy Act include setting the energy efficiency standard for new builds (nearly zero-energy building standard) as required by the 2010 EU Energy Performance of Buildings Directive (EPBD).

By March 2020, the Federal Government also must implement the EPBD amending directive that entered into force in July 2018. Aside from changes in the requirements for technical building systems, the revised Directive requires EU Member States to present a renovation strategy to support renovation of the national building stock.

67 – 66 %

The Federal Government's Climate Action Plan sets a target for the buildings sector of an at least 67 to 66 per cent reduction in greenhouse gas emissions by 2030 compared to 1990.

3.7 Agriculture

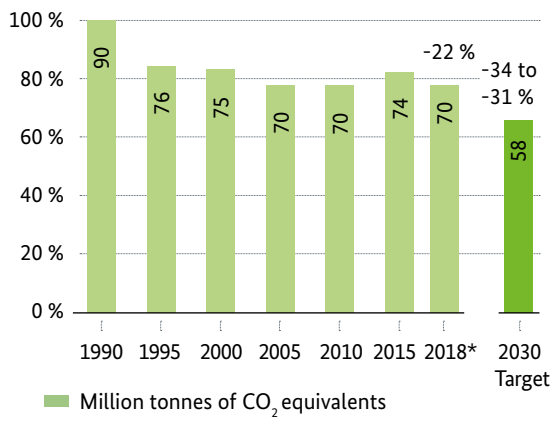
Emissions development

Agriculture was responsible for 66.3 million tonnes of CO_2 equivalents, or a 7.3 per cent share of Germany's total emissions in 2017. It is estimated that emissions fell by 4.1 per cent in 2018 to 63.3 million tonnes of CO_2 equivalents. Between 1990 and 2017, overall emissions were cut from 90 million tonnes of CO_2 equivalents by 26.3 per cent, though since 1995 there have been only slight fluctuations between the years (Figure 34). The sharp fall in the years immediately following the reference year 1990 is due mainly to the decline in livestock numbers as the Federal States of the former East Germany underwent structural change. Further emission reductions were achieved due to the environmental requirements of the EU's Common Agricultural Policy, and through better fertiliser management. It should be noted that indirect emissions – arising for example because of land use changes or drained peaty soils – are not counted when calculating the agriculture sector's footprint. Total emissions from the agriculture sector therefore do not include CO_2 from the agricultural use of organic soils, as these emissions are attributed to LULUCF sector (LULUCF, see Section 3.8).

The greenhouse gases from agriculture that are taken into account in this sector have a very different composition compared to those in other sectors. Carbon dioxide makes up a large portion of total greenhouse gases, and the majority is due to the extremely potent greenhouse gases CH_4 and N_2O (see Figure 35 and Box 1 on greenhouse gases). Methane is produced in the ruminant digestive process, which is why cattle farming accounts for a large part of the emissions from agriculture. Nitrous oxide emissions are also produced in animal husbandry, and by nitrogen fertilisers.

Agriculture makes a significant contribution to emissions, but at the same time is particularly affected by the impacts of climate change. For example, rising temperatures and clusters of extreme weather events can significantly affect harvest yields. This became clear during the summer of 2018 as a result of the high temperatures (see Section 1.1).

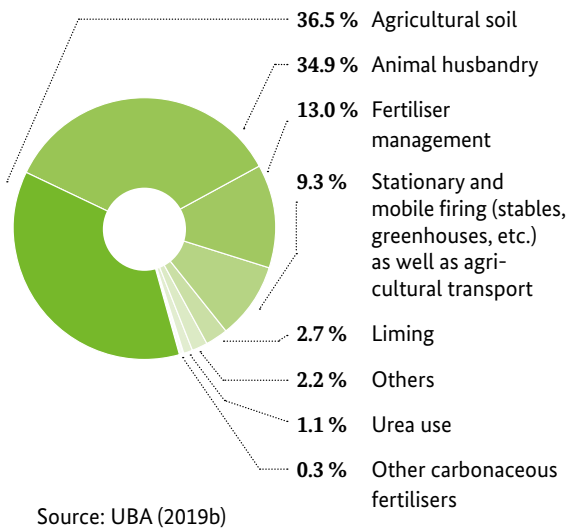
Figure 34: **Emissions development in the agriculture sector**



* Estimate

Sources: UBA (2019b), UBA (2019c)

Figure 35: **Emission sources in the agriculture sector in 2017 (excluding CO_2 from biomass)**



Source: UBA (2019b)

Current political measures

Action areas in the agriculture sector include increasing nitrogen efficiency, maintaining the carbon storage function of agricultural soils, more efficient fertilisation and lower emissions from livestock farming. Increasing the area share of organic farming helps to cut greenhouse gas emissions per hectare, particularly because mineral fertilisers and chemical / synthetic pesticides are not used.

Compared to the other sectors, the reduction target appears low at first glance. This is because there are limited possibilities to cut emissions through technological solutions. **A certain minimum amount of greenhouse gas emissions cannot be completely avoided due to natural biological processes in livestock and crop production.** A balance therefore needs to be found, where the remaining emissions are absorbed again by natural sinks.

The Federal Government aims to increase the area share of organically farmed land in the total area used for agriculture in Germany from 8.2 per cent at present to 20 per cent by 2030.[38] In 2017 11.0 per cent of farms were organic. In Germany, the Federal Scheme for Organic and other Forms of Sustainable Agriculture makes 17 million euros available annually. This complements the funding provided under the EU's Common Agricultural Policy (CAP).

Increasing fertiliser efficiency means reducing excess nitrogen and improving nitrogen utilisation. Requirements for fertilisation are set out in the Fertiliser Ordinance (DüV) and in the Fertiliser Act (DüngG), both of which were revised in 2017. In addition, the new ordinance on handling nutrients in farms and substance flow analyses for farms (Substance Flow Analysis Ordinance) entered into force on 1 January 2018. The tighter rules are primarily aimed at ensuring sustainable and resource-efficient management of nutrients on farms as a way of controlling water pollution and reducing greenhouse gas emissions.

After the European Court of Justice (ECJ) ruled against Germany in June 2018 for exceeding the limits specified in the EU's Nitrate Directive, the Federal Government submitted proposed changes for another revision of the Fertiliser Ordinance to the European Commission in January 2019 to comply with the court ruling.

34 – 31 %

The Federal Government's Climate Action Plan sets a target for the agriculture sector of at least a 34 to 31 per cent reduction in greenhouse gas emissions by 2030 compared to 1990.

At European level, the CAP has impacts on climate action in the agriculture sector. The design and national implementation of the CAP affects farming methods and intensity. In total, around 6.3 billion euros of EU funds is available each year for agricultural support programmes in Germany from 2014 to 2020. The first pillar of support provides direct payments to land managers. The second provides funding for rural development and must be co-financed with national funds.

Since the CAP reform in 2013, the first pillar has included a greening component that flows into the direct payments. Accordingly, roughly 30 per cent of national direct payments are linked to mandatory management requirements such as crop diversification, preservation of permanent grassland and the establishment of ecological priority areas.

The second pillar comprises targeted measures, including the support of the transition to organic farming. In June 2018, the European Commission presented legislative proposals for the future of the CAP after 2020, to be implemented in the 2021 to 2027 funding period.[39] These are currently being discussed in the EU Council of Ministers.

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Nitrogen management

Increasing nitrogen emissions are one of the greatest environmental problems. Nitrogen pollution can take the form of high nitrate content in groundwater, for example, or – especially in cities – nitrogen dioxide pollution in the air. In May 2017, the Federal Cabinet adopted a report on nitrogen input into the environment, in a move that firmly placed this topic on the political agenda for the first time. The Federal Government aims to reduce nitrogen to an environmentally friendly and healthy level via a cross-sectoral approach. In its report, the Federal Government announced it was preparing an action programme for nitrogen reduction. The programme is intended to help better identify and strengthen synergies between the various Federal Government programmes.

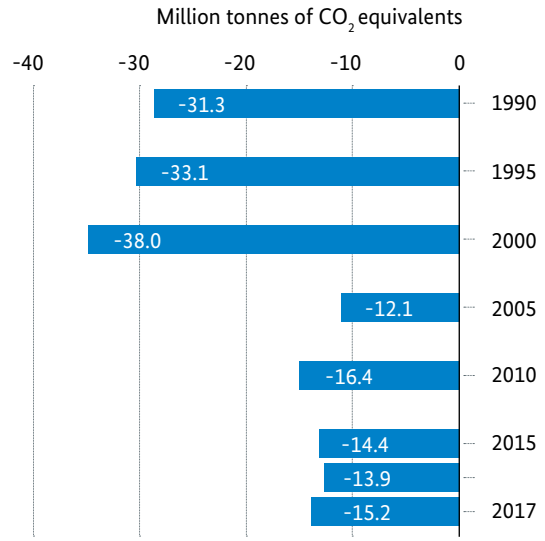
3.8 Land use, land use change and forestry (LULUCF)

Emissions development

The LULUCF sector acts as a sink for CO_2 emissions. In 2017, it had the effect of reducing overall emissions by 15.2 million tonnes of CO_2 equivalents (Figure 36). The LULUCF sector is important for achieving "negative emissions", which means the removal of greenhouse gases – mainly CO_2 – from the atmosphere. Depending on how they are used, areas of land can either emit or store greenhouse gases (Figure 37). If the type of land use changes, this has impacts on the national carbon balance. The footprint of the LULUCF sector is calculated via an equilibrium model that divides the national territory into forests, arable land and grassland, wetlands, settlements and land with other uses. Forests, arable land and grassland areas are particularly relevant in Germany.[40] The sector's impact is a product of the difference between stored and emitted greenhouse gases. Intensive farming has reduced the storage capacity of agricultural soils in Germany by more than half since 1990. The release of greenhouse gases is due in particular to the conversion of grassland into arable land, the agricultural use of arable land and the drying of peatlands. In Germany, forests are the main sink. EU Member States have to produce regular reports on the carbon balance in the LULUCF sector. A carbon inventory is carried out every four years for this purpose. Additional information on the development of forests is provided by the national forest inventory, which is conducted every ten years in Germany.

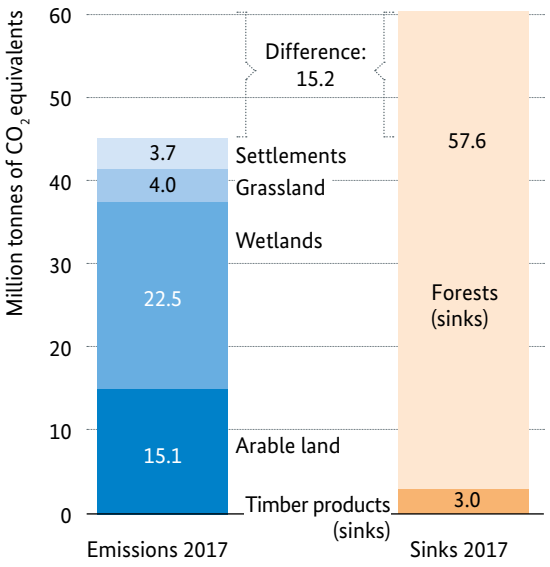
Emissions from the LULUCF sector were not previously taken into account when assessing the achievement of national and European climate action targets. This is partly because of the methodological difficulties in recording the storage effect, and also the possibility of unpredictable external influences on the storage capacity of soils and vegetation, such as forest fires and insect attacks. In 2017, the EU decided that these emissions would have to be included in future targets, and that countries would have to ensure that the sector is maintained as a sink.

Figure 36: **Emissions development in the LULUCF sector (including sinks)**



Source: UBA (2019b)

Figure 37: **Emissions and sinks in the LULUCF sector in 2017**



Source: UBA (2019b)

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Peatlands

Peatlands are wetlands that are thousands of years old and are natural carbon stores. They are found particularly in the north and south of Germany. Today, 90 per cent of the areas that were originally peatlands have been drained and, in the vast majority of cases, converted to agricultural use. They are in a degraded state.

Peatlands can store much more CO_2 equivalent per square metre than forests for example, even though the latter can store CO_2 more quickly. Peatlands contain large quantities of peat, an organic sediment that consists of partially decayed vegetation. When peatlands are drained, the peat decomposes, releasing CO_2 and a small amount of nitrous oxide. In the EU, Germany is the largest emitter of greenhouse gases from peatlands after Finland, despite the fact that they only cover a relatively small percentage area of the country. Total emissions from peatlands used for agriculture in 2016 amounted to around 38 million tonnes of CO_2 equivalents, which is more than four per cent of the national total greenhouse gas emissions.[41] To reduce this relatively high figure, rewetting dried peatland areas is a priority action.

Current political measures

Action areas in the LULUCF sector include maintaining and improving the sink capacity of forests, sustainable management and timber usage, the preservation of permanent grassland and peatlands, and soil-friendly farming methods. The National Biodiversity Strategy (NBS) sets a target that the area share of forests with natural forest development should be five per cent of Germany's total forest area by 2020. In 2013, roughly two per cent of forest area was permanently secured for natural forest development. The total is currently being updated in a research project called "Natural forest development in Germany: perspectives and potentials for the development of a coherent NWE system" (NWePP). The results will be available in early 2019.

At European level, the "Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry" (LULUCF Regulation) was approved by the European Parliament in April 2018. The Regulation comes into force in mid-2020, and covers the land categories of managed forests, afforested areas, deforested areas, managed cropland and managed grassland. Member States have to ensure that in the periods 2021 to 2025 and 2026 to 2030, overall total emissions in all land reporting categories do not exceed the overall reduction of greenhouse gas emissions. Member States can swap CO_2 reduction values with each other as part of an accounting system. Managed wetlands will be included in the scope of the regulation from 2026 at the latest.

The preservation of permanent grassland is already part of "greening" under the EU's CAP. It means that around 30 per cent of the national direct payment upper limits are linked to climate- and environment-friendly land management.

4. Towards a greenhouse gas neutral society

Summary

A greenhouse gas neutral future is **technologically possible and brings economic and social benefits**. Innovative technologies and our lifestyles play an essential role in making the necessary transformation. Many of these technologies already exist today, and open up possibilities for manufacturing industry in Germany to **develop new domestic value chains**. On the journey to a greenhouse gas neutral future, **modernising existing infrastructure** is a key task. Modernisation in transport, the buildings sector, the energy supply and in communication and information technologies represents an opportunity to **bring infrastructures in line with climate action and climate preparedness goals**. Over half of the population in Germany thinks that the goal of greenhouse gas neutrality is very important. Through **sustainable action**, everyone can help to protect the environment. **Creating a sustainable financial system** also plays an important role in implementing climate policy measures.

Many of the necessary **transformation processes are already taking place**. Overall, **climate action can be expected to have a positive effect on the economy and on jobs.** An active and forward-looking climate policy can increase predictability and **investment security for businesses and private individuals.** It is vital that policymakers proactively anticipate and respond to change but **avoid sudden upheavals**.

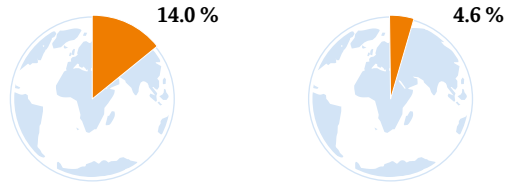
4.1 Enterprise and innovation

Environment- and climate-friendly technologies are a vital pillar of Germany's industrialised society. Environmental techniques and technologies to enhance resource efficiency ("GreenTech") already play an important role in the German economy. In 2016, the GreenTech industry accounted for 15 per cent of GDP.[42] By 2025, the GreenTech industry's share of GDP could rise to 19 per cent, representing an annual growth rate of 8.8 per cent. Developing new forward-looking technologies allows markets to be developed early on and allows market positions to be improved. This creates additional export opportunities for German businesses, which helps to ensure prosperity and secure jobs in Germany.

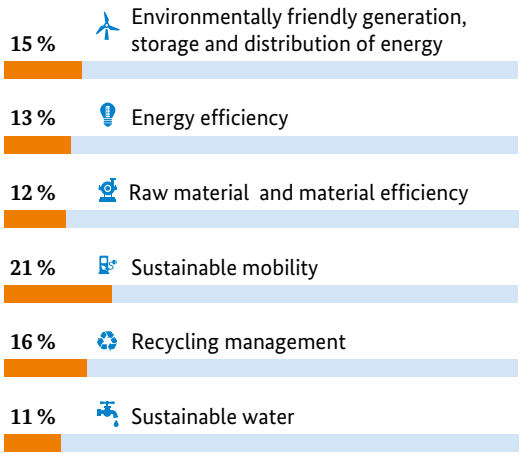
In 2016, GreenTech had a global market volume of more than 3,200 billion euros. German companies had a 14 per cent share of that total. For comparison, Germany's overall share of global economic output was 4.6 per cent (Figure 38). This shows that German environmental technologies already have a disproportionately high importance in international markets. It can be assumed that this sector will continue to gain in significance. Another key indicator of an economy's innovative strength is the number of patent applications. Based on the global distribution of patents held, it is possible to see which countries are significant technology leaders. It is notable that the EU (with Germany) dominates climate-friendly technologies, with a global share of 38.8 per cent.[43] With more than 40 per cent of EU patents, Germany has significant specialisation advantages in renewable energies and in efficient energy conversion and use.

Lead markets for renewable energies and energy efficiency are on a growth trajectory. The market volume for climate-friendly energy generation, storage and distribution in Germany is forecast to grow from 79 to 135 billion euros between 2016 and 2025.[44] The fastest growth is happening in storage technologies: this market segment will grow at an average annual rate of 15 per cent until 2025. The volume of the energy efficiency market in Germany stood at 83 billion euros in 2016. The increasing importance of energy efficiency as a central lever for lowering greenhouse gas emissions is reflected in the projected market trend. With annual growth of 9.1 per cent, the market volume in Germany will rise to 182 billion euros by 2025.[45]

Figure 38: **Germany's share in the global environmental technology and efficiency market (left) and in global economic output (right) 2016**



German businesses' share of the global market for environmental technology and energy efficiency



Source: BMU (2018b)

The implementation of climate goals has positive impacts on the German economy. According to an impact assessment commissioned by BMU for the sectoral goals of the Climate Action Plan, achieving the sectoral targets for 2030 will require additional investments of 240 to 270 billion euros in the period from 2018 to 2030.[46] The calculated investment requirement is largely offset by savings resulting from modernisation and efficiency increases. These savings include, for example, lower energy, operating and maintenance costs, as well as lower insurance costs. In addition, stronger overall economic growth is anticipated. This results from the increased level of investment and the fall in demand for imported fossil fuels. Furthermore, positive impacts are expected on value creation, GDP and employment.

Digitalisation can benefit the environment. Substantial emission savings in many areas are facilitated or

enabled for the first time by digitalisation. It supports sector coupling, for example: intelligent solutions allow temporary electricity surpluses to be better utilised or stored both in industrial processes and in the transport sector. Intelligent building services technology can cut heat consumption, optimise delivery processes, avoid empty runs and reduce fuel consumption in the logistics sector. Digitally controlled, intelligent transport systems and improved information systems can optimise traffic flows and shorten or avoid particular routes (such as when looking for a parking space). Furthermore, phone and video conferencing replace business travel. Nevertheless, the increased electricity consumption of servers and data centres – which are also part of digitalisation – has a negative impact on the environmental balance.

> *"Economic output will be 1.1 to 1.6 per cent higher in 2030 if we invest in climate action."*
> *Jochen Flasbarth, State Secretary at the BMU*

Business models in the sharing economy are supported by digital information and exchange platforms. These have the potential to promote more sustainable consumer behaviour, for example by optimising the use of existing means of transport. Sharing concepts are already increasingly used in urban centres, enabling situational and pragmatic decisions when choosing the best way to travel. Car sharing services, for example, can reduce environmental impacts. This is dependent on low-emission technologies being used in the shared cars, and car sharing should not weaken other environment-friendly options such as public transport. Moreover, a positive effect can only be achieved if sharing models simultaneously displace high-emission alternatives.

Climate action has many additional benefits. In the energy sector, the expansion of renewable energies and the increase in energy efficiency are already reducing dependency on energy imports such as oil and gas. The BMWi estimates that in 2015, had it not been for the expansion of renewable energies and energy efficiency measures, additional expenditure for energy imports would have totalled 16 to 18 billion euros. Switching from fossil fuels to renewables in electricity and heat generation or in transport also helps to reduce air and noise pollution.

4.2 Jobs and structural change

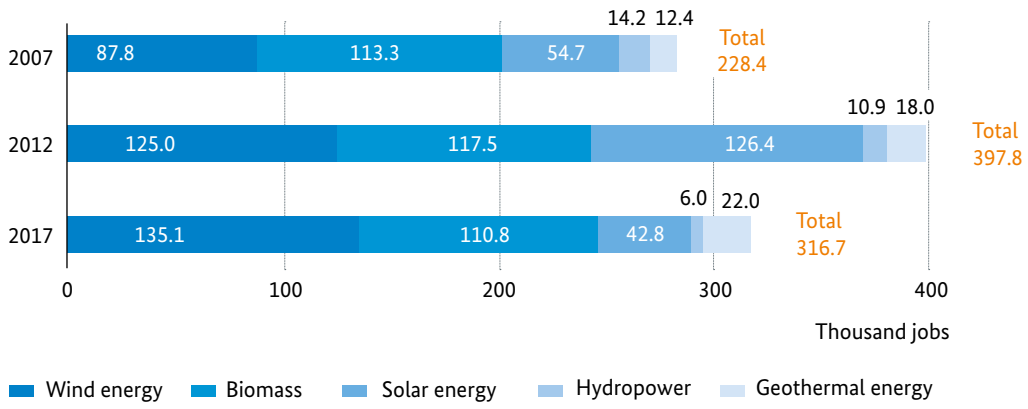
Climate action is already a major driver of employment. In recent years, there has been a noticeable shift from jobs in the conventional energy sectors towards renewable energies. Figure 39 shows the jobs trend in the renewable energy sector. In 2017, around 316,700 people were employed in the renewable energies sector.[47] The number of employees has therefore fallen by 24 per cent since 2011, when employment in this sector was at a peak. The decrease in the solar energy segment is due to rising international competition. Expansion of the wind energy segment is currently being slowed by changed legal frameworks, administrative hurdles and local resistance. In the renewable energies sector, however, wind power is still the driving force in Germany, accounting for 43 per cent of employees.[48]

The cross-sectoral industry of environmental technology and resource efficiency employed around 1.5 million people in 2016. Along with renewable energy technologies, this includes the employment areas of energy efficiency, raw material and material efficiency, sustainable mobility, recycling management and sustainable water management.

Energy efficiency in particular is a major job creator. Investments in the energy refurbishment of buildings provided jobs for more than half a million people in 2016.[49] Additional employment is created for example through efficiency services such as energy consulting, energy contracting and energy management. New jobs also result from the increasing demand for energy-efficient production processes in industry and energy-efficient end products, such as domestic appliances or entertainment electronics.

Overall, climate action will have a positive impact on employment. A study by the BMU showed that by 2030, climate action will create the need for an additional 307,000 to 427,000 employees.[50] Significant growth in employment is also expected in the trade and other services and construction and building trades sectors. By contrast, falling employment is forecast in the lignite industry (mining and power plants). Significant shifts are anticipated in automotive manufacturing. Reductions in employment in conventional car production occur alongside job growth in manufacturing

Figure 39: **Development of gross employment due to renewable energy sources in Germany**



Source: BMWi (2018a)

cars with alternative drive technologies. This growth occurs at the component manufacturing level (electric motor, battery, control electronics and so on).

It is essential to cushion the social impacts of structural change. Many of the described changes to new technologies and new jobs will have major structural consequences for employees. For example, the change resulting from a gradual phase-out of lignite in the Rhenish, central German and Lusatian coal mining areas requires policy support. To this end, the Federal Government appointed the K-WSB on 6 June 2018, comprising 28 representatives of industry, business, trade unions, environmental groups and the affected coal regions. The commission's goal was to propose a phase-out plan for coal-fired generation, including an end date. At the same time, the commission was tasked with identifying real prospects for new, secure jobs in the affected regions, and developing proposals for sustainable, forward-looking structural development. By a large majority of all parties involved, the commission adopted its proposals and published a final report on 26 January 2019.

"The recommendations of the 'Commission on Growth, Structural Change and Employment' send a very strong signal for lower CO_2 emissions, more new jobs, a secure energy supply and affordable electricity." Peter Altmaier, Federal Minister for Economic Affairs and Energy, on the K-WSB report

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Recommendations of the Commission on Growth, Structural Change and Employment on structural change in Germany

The coal regions should receive financial assistance for structural change. The Federal Government should provide additional funds for the affected regions, spread over approximately 20 years. A substantial portion of these funds should be earmarked for infrastructure development, promoting enterprise and innovation, and for the location and establishment of government agencies and research institutions in the regions.[51]

Specific measures to accompany structural change should be set out in a legislative package. The industry and energy foundations of the coal regions should continue to be developed. Targeted support should reduce the negative impacts of the coal phase-out on employees and create new employment prospects.

The affected regions should be transformed into viable energy regions. More support should be directed towards the use of renewable energies, energy storage and other forward-looking energy technologies in the affected regions.

Particular attention should be given to surmounting structural weaknesses in infrastructure. For example, the economically underdeveloped coal regions in central Germany and Lusatia could be more closely integrated by building an east-west road link. Lusatia and the Rhineland area should become mobility clusters for researching climate-friendly, state-of-the-art mobility.[52]

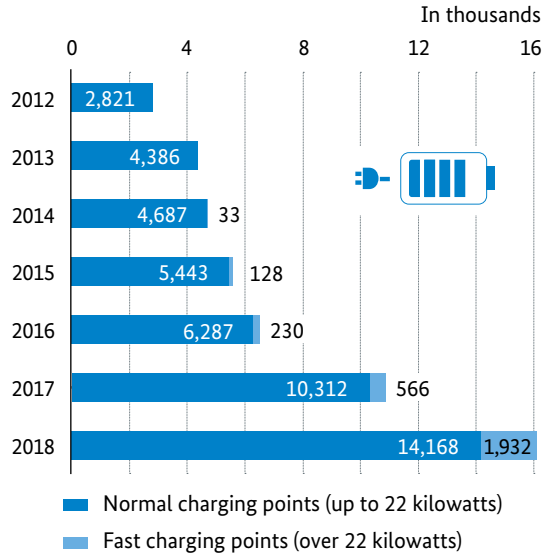
4.3 Creating sustainable infrastructures

Sustainable infrastructures are key to achieving a greenhouse gas neutral society. Considerable modernisation potentials exist in many areas. Especially infrastructures that are available to the public should enable emission-free economic activity and at the same time be resilient to the impacts of climate change. Because of the long investment cycles, climate mitigation and adaptation should be taken into account today in the expansion and modernisation of infrastructures. This particularly applies to the provision of energy in electricity and gas grids, to transport routes, and to information and communication infrastructure, since these cross-sectoral infrastructures can help reduce emissions in all sectors. Modernisation measures that are required in any case represent an opportunity to bring infrastructures into line with climate action and climate preparedness goals.

The energy transition creates new challenges for the electricity networks. The distances between the production centres of renewable energies and the centres of consumption, and the increasing demand for electricity owing to the increased use of electricity-based applications such as electric heat pumps and electromobility, call for the optimisation and expansion of electricity networks. The Federal Government is therefore advancing the construction of new transmission lines. An amendment to the Transmission Network Expansion Acceleration Act is aimed at simplifying and speeding up the approval process for network construction projects. The Federal Cabinet approved draft legislation in December 2018. Other infrastructure challenges include the modernisation of distribution networks and improvements in the management of electricity networks.

The transformation of transportation requires state-of-the-art infrastructure. Development of a publicly accessible charging infrastructure is crucially important for the increasing electrification of road transport. The number of charging points in Germany is constantly increasing (see Figure 40 and Section 3.5). The expansion of charging infrastructure is currently still heavily focused on towns and cities. For a nationwide charging infrastructure, it is important that expansion takes place in rural areas too.

Figure 40: **Development of charging infrastructure for electromobility in Germany**



Sources: BDEW (2017), BDEW (2019)

The Federal Government's goal is to install 100,000 additional charging points by 2020.

4.4 Sustainable consumption

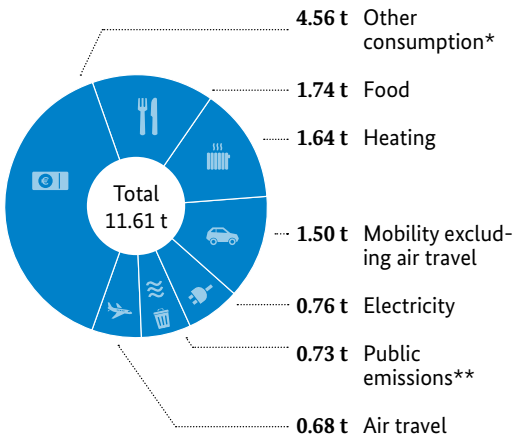
Over half of the population in Germany thinks that the goal of greenhouse gas neutrality is very important. The Federal Government's environmental awareness study shows that over 90 per cent of those surveyed supported further political measures to mitigate climate change and protect the environment.[54] At the same time, every individual can also help to reduce per capita emissions. In the case of electricity consumption, consumers have the option to buy green electricity; they can also identify and use the most efficient home appliances via energy efficiency ratings. When it comes to food and transport, consumers can avoid emissions, for example by choosing a plant-based diet, opting for seasonal and regional produce, and avoiding car journeys and flights (Figures 41 and 42).

The Federal Government specifies framework conditions to facilitate sustainable action. By adopting the National Programme for Sustainable Consumption in 2016, the government set itself a collective target to bring sustainable consumption from a niche status to mainstream.[55] To this end, cross-sectoral approaches to

Moreover, expansion and modernisation of the rail network is important for shifting traffic to rail (see Section 3.5). The current Federal Transport Infrastructure Plan budgets investment of 112.3 billion euros for this purpose by 2030.[53] The share of cycling and walking in total kilometres travelled can also be increased, especially in urban areas. This requires a well-developed cycle path network, accessible pedestrian routes and access to public transport. The Federal Ministry of Transport and Digital Infrastructure (BMVI) provided more than 130 million euros for improving cycling infrastructure in 2018. Many cities and Federal States implement their own policies to support modern, emission-free transport.

Digitalisation can enable the development of major climate-friendly technologies. To unleash the potentials of digitalisation, it is important to improve information and communication infrastructure, including nationwide mobile network and mobile internet coverage. Another step is to roll out the 5G frequency, which would enable significantly higher connection speeds. The 5G spectrum auction began in March 2019.

Figure 41: **Average annual greenhouse gas footprint of a German citizen**



* For example clothing, domestic appliances and leisure activities.
** For example water supply and disposal, waste disposal

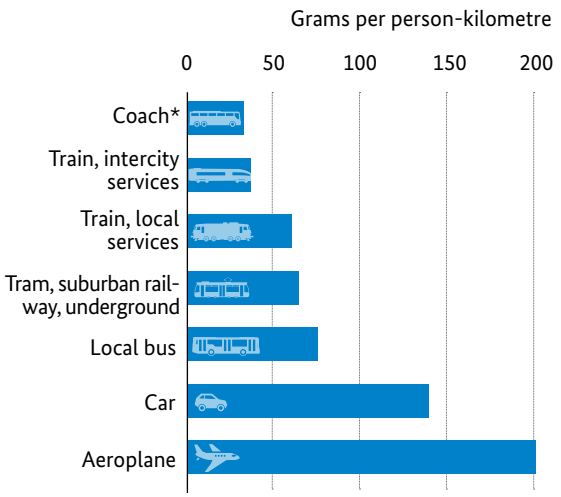
Source: UBA (2019f)

a policy for sustainable consumption are defined, and specific measures described. These include expanding information services like the UBA consumer advice portal on environmentally conscious living[56] and increased communication and advertising for the use of personalised information tools such as CO_2 and resource calculators.

Product labelling ensures that consumers are better informed. The Federal Government's voluntary ecolabel, the Blue Angel, was introduced in 1978 and indicates the most environmentally friendly products and services in numerous categories. The voluntary EU Ecolabel also identifies a number of comparatively advantageous products from the environmental viewpoint. The mandatory EU framework regulation for energy labelling makes it easier for consumers to incorporate information factors like energy consumption and noise emissions into their purchase decision. Together with voluntary ecolabels, this instrument promotes market penetration by the most resource and / or energy efficient technology within a particular product group (top runner approach).

Figure 42: **Average emissions in passenger transport**

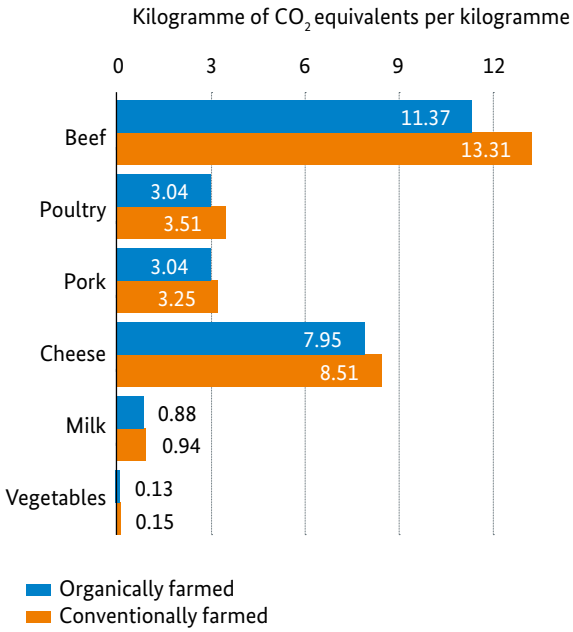
Greenhouse gases as CO_2 equivalent – base year 2017



*Long-distance coach journeys and coach tours

Source: UBA (2018j)

Figure 43: **Climate footprint of foodstuffs**



Organically farmed produce (top bar in each case) has a better overall climate footprint than conventionally farmed produce (bottom bars).

The climate footprints shown are based on food life cycle analyses. These analyses include all greenhouse gas emissions attributable to the food. Such emissions occur for example during production, processing and transportation.

Source: BMU (2016b)

4.5 Sustainable finance

The impacts of climate change constitute a threat to many business models. Risks include economic losses for businesses due to extreme weather events, loan defaults for banks and the danger of an asset bubble in fossil fuels. So far, these environmental and climate risks have not been systematically taken into account in the investment decisions of private and institutional investors and asset managers such as banks, insurance companies and pension funds.

The financial system is not sustainable in its current form. To limit the global temperature increase to 2°C, at least two thirds of all known fossil reserves worldwide must remain unused. Yet financial institutions continue to invest billions in coal, oil and gas companies. In light of political targets, these investments are increasingly becoming a financial risk. As climate policy measures are implemented, fossil investments could lose their value and become "stranded assets". In addition, extreme weather events are already causing billions of euros of economic losses every year. The countries of the Paris Agreement therefore made a commitment in Article 2.1 to bring finance flows into line with low-carbon and climate-resilient development goals.

To create a more sustainable financial system, environment- and climate-related risks to investments must be made transparent and systematically taken into account in financial asset valuations. The European Commission has therefore developed an Action Plan on Financing Sustainable Growth. The action plan has three main objectives that strengthen a sustainable financial system.[57] Firstly, capital flows should be reoriented towards sustainable investment,[58] to achieve sustainable and inclusive growth ("sustainable finance package"). Measures include introducing an EU classification system for sustainable economic activity, disclosure obligations regarding the sustainability of investments for institutional investors and asset managers (insurance companies, pension funds and so on) the introduction of benchmarks for lower CO_2 emissions, and a requirement to provide investors with better information on the sustainability of their investments. An EU classification system for sustainable economic activities would enable a clear definition of whether a given economic activity is environmentally sustainable. This definition is still disputed. With the proposed measures, asset managers and institutional investors could better integrate environmental, social and governance (ESG) criteria into their investment decision process. They could better estimate the sustainability risks involved in investments, as well as their environmental and social impacts.

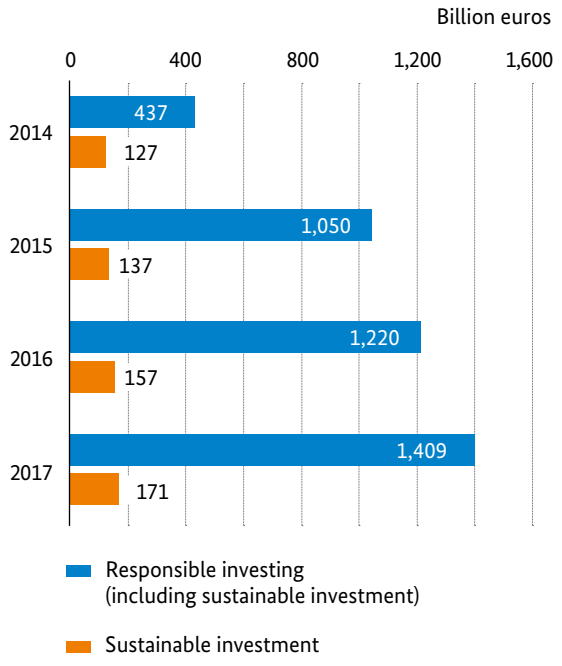
The implementation of climate policy measures requires significant additional investment. The private financial sector therefore plays a key role in climate action. Current investments are insufficient to achieve the EU's climate and energy goals by 2030. According to European Commission forecasts, almost 180 billion euros of additional investment funds will be required in the energy efficiency and renewable energies sectors in the EU, between 2021 and 2030.[59] For the transport, energy and resource management sectors, the European Investment Bank (EIB) puts the annual investment gap at an estimated 270 billion euros.[60] These investment challenges exceed the capacity of the public sector alone. As the key actors in the private finance sector, banks, insurance companies and pension funds have an important role to play in closing the gap for the transition to a more sustainable economy. According to Forum Nachhaltige Geldanlagen (FNG), the investment volume for what is considered to be "responsible investing" stood at 1,409 billion euros in 2017 (Figure 44). This equates to a share of just 3 per cent of total investments in Germany.[61] Responsible investments are those which take ESG criteria into account.

Private investors, too, already have opportunities to invest their money sustainably. There has been significant growth in the offering of sustainable current accounts and savings / investment products in recent years. Banks with sustainability standards can assure their customers that their money does not fund the defence, nuclear or oil industries, and that financing decisions take businesses' sustainability into consideration. With sustainable investments such as sustainability funds or ethical funds, investors specifically invest in companies that meet certain criteria. These may relate to particular environmental or social aspects (such as production

180 bn

In the EU, 180 billion euros of additional investment funds will be required in the energy efficiency and renewable energies sectors between 2021 and 2030.

Figure 44: **Volume of sustainable investments and responsible investing in Germany**



Source: FNG (2018)

conditions). More transparency in the advice given to customers, as is required under the European Commission's package of measures, would enable private citizens to make more targeted investment decisions.

> *"It is fundamentally important to mobilise private capital to finance sustainable investments." Jyrki Katainen, European Commission Vice-President for Jobs, Growth, Investment and Competitiveness*

5. Glossary

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

Carbon leakage
Due to CO_2 pricing or strict climate regulations, industrial production is outsourced to countries where no climate action requirements or low requirements apply. This also outsources the associated (climate gas) emissions.

Climate resilience
Reducing vulnerability to the impacts of climate change, and maintaining and increasing the capacity of natural and social systems to adapt to inevitable climate impacts.

CO_2 equivalent
For better comparability, emissions of greenhouse gases other than carbon dioxide (CO_2) are converted into CO_2 equivalent according to their global warming potential (CO_2 = 1).

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

Damage costs
Costs of remedying climate impacts. By contrast, adaptation costs are incurred in advance, in preparation for anticipated climate impacts.

Decarbonisation
Increasing use of low-carbon and carbon-free sources of energy for economic activity.

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

Effort Sharing Decision (ESD)
EU decision requiring Member States to reduce their GHG emissions from non-ETS sectors by a total of ten per cent by 2020 compared to 2005 and to distribute this target among the individual Member States.

Effort Sharing Regulation
EU decision requiring Member States to reduce their GHG emissions from non-ETS sectors by a total of 30 per cent by 2030 compared to 2005 and to distribute this target among the individual Member States.

Energy productivity
Ratio of total economic output to the energy used (inverse of energy intensity).

EU Emissions Trading System (EU ETS)
Since 2005, emissions trading has been the central EU-wide instrument for reducing CO_2 emissions, making it the main instrument for implementing the EU's climate goals. It covers emissions from businesses in the energy and industry sectors, which can trade emission allowances with each other.

European Climate Initiative (Europäische Klimaschutzinitiative, EUKI)
BMU funding programme to promote cooperation within the EU in the further development and implementation of its climate policy.

External environmental costs
Costs (particularly of environmental damage) that are incurred when producing economic assets, but are not borne by the producer.

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

Feed-in tariff
Remuneration for electricity from renewable energy sources defined by the government and enshrined in the EEG.

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

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

Global warming potential (GWP)
Measures the harm to the climate caused by one molecule of a greenhouse gas. The global warming potential of carbon dioxide is used as a benchmark to define the GWP of other greenhouse gases.

Greenhouse gas neutrality
Reached when the total of anthropogenic greenhouse gas emissions (for example from 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 that offer environmentally friendly, sustainable, and resource- and energy-saving technologies, services and products.

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

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

International Climate Initiative (Internationale Klimaschutzinitiative, IKI)
BMU funding programme for climate and biodiversity projects in developing and emerging countries as well as in transition states.

Level of confidence
IPCC findings are based on an assessment of the scientific evidence and the extent to which it is consistent. A level of confidence is expressed using five qualifiers: very low, low, medium, high or very high.

National Climate Initiative (NCI)
BMU funding programme for climate action.

Person / tonne kilometres
Person-kilometres (pkm) and tonne-kilometres (tkm) are calculated by multiplying vehicle kilometres travelled by the number of people or volume of freight transported.

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

Power-to-X
To enable long-term storage of renewable electricity generated at low cost, and allow it to be used in other sectors, an increasing range of different technologies are used to convert (surplus) electricity into other energy sources. 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.

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

Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz, EEWärmeG)
The Law Promoting Renewable Energy in the Heating Sector is from 2009. It obliges the owners of new buildings to meet part of their heating and cooling needs from renewable energy sources. The first amendment to the act entered into force in 2011.

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

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

Source principle
Allocation of emissions to the point of origin.

Sustainable Development Goals (SDGs)
The global Sustainable Development Goals were adopted in 2015 as part of the United Nations Agenda 2030. The 17 goals address for the first time all three dimensions of sustainability – society, environment and economy – and are mutually interdependent.

Sustainable investments
Investments that explicitly take ESG criteria into account in their investment conditions. This implies an explicit, written investment policy on the application of ESG criteria.

Temperature anomaly
Deviation of the annual temperature from long-term average temperature values that serve as a reference period. The German Meteorological Service (DWD) uses the internationally applicable reference period of 1961 to 1990, with a reference value of 14.0 °C for the annual mean temperature.

Tenders
Since the EEG 2017, tenders have been used to determine the level of feed-in tariffs for selected renewable energy sources competitively. The lowest bids are awarded the contract and their implementation is subsidised.

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

6. Abbreviations

AGEB	Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)
AGEE	Working Group on Renewable Energy (Arbeitsgruppe Erneuerbare Energien)
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)
BMWi	Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
bn	Billion
CAP	EU Common Agricultural Policy
CH_4	Methane
CHP	Combined heat and power
cm	Centimetre
CNG	Compressed natural gas
CO_2	Carbon dioxide
COP	Conference of the Parties
CTS	Commerce, trade and services
DAS	German Climate Change Adaptation Strategy (Deutsche Anpassungsstrategie an den Klimawandel)
DEHSt	German Emissions Trading Authority (Deutsche Emissionshandelsstelle)
DWD	German Meteorological Service (Deutscher Wetterdienst)
ECJ	European Court of Justice
EDGAR	Emission Database for Global Atmospheric Research
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EIB	European Investment Bank
EPBD	Energy Performance of Buildings Directive
ESR	Effort Sharing Regulation
EU	European Union
EU ETS	EU Emissions Trading System
EU28	28 Member States of the European Union
EUKI	European Climate Initiative (Europäische Klimatschutzinitiative)
F-gas	Fluorinated greenhouse gas
FEP	Final energy productivity
FNG	Forum Nachhaltige Geldanlagen
G20	Group of the 20 largest industrialised and emerging economies
GDP	Gross domestic product
GHG	Greenhouse gas
HFC	Hydrofluorocarbon
IKI	International Climate Initiative (Internationale Klimaschutzinitiative)

IPCC	Intergovernmental Panel on Climate Change
KfW	German development bank (Kreditanstalt für Wiederaufbau)
KWKG	Combined Heat and Power Act (Kraft-Wärme-Kopplungsgesetz)
K-WSB	Commission on Growth, Structural Change and Employment (Kommission "Wachstum, Strukturwandel und Beschäftigung")
LPG	Liquefied petroleum gas
LULUCF	Land use, land use change and forestry
m	Million
NAPE	National Action Plan on Energy Efficiency (Nationaler Aktionsplan für Energieeffizienz)
NCI	National Climate Initiative (Nationale Klimaschutzinitiative, NKI)
NDC	Nationally Determined Contributions
NEDC	New European Driving Cycle
NF_3	Nitrogen trifluoride
NWE	Natural forest development (Natürliche Waldentwicklung)
PEC	Primary energy consumption
PEP	Primary energy productivity
PFC	Perfluorocarbon
ProgRess II	German Resource Efficiency Programme II (Deutsches Ressourceneffizienzprogramm II)
SF_6	Sulphur hexafluoride
t	Tonne(s))
UBA	Federal Environment Agency (Umweltbundesamt)
UNFCCC	United Nations Framework Convention on Climate Change
WLTP	Worldwide Harmonized Light-Duty Vehicles Test Procedure (standardised, EU-wide type approval test procedure for new cars)

7. Endnotes

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2. Coumou, D. et al. (2013)
3. IPCC (2018)
4. UBA (2016), UBA (2018a)
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8. UNFCCC (2019a)
9. UNFCCC (2019b)
10. Navigant, New Climate Institute, Climate Analytics (2018)
11. Navigant, New Climate Institute, Climate Analytics (2018)
12. BMZ (2018)
13. IPCC (2018)
14. IDMC (2018)
15. World Bank (2018a)
16. Euractiv (2019)
17. Agora Energiewende (2019)
18. EEX (2019)
19. BMU (2018a)
20. BMU (2018c)
21. Agora Energiewende (2019)
22. European Commission (2019)
23. Own calculation based on provisional figures from AGEB (2018)
24. Federal Government's 2010 Energy Concept
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26. AGEB (2018)
27. BMU (2018a)
28. BMU (2018c)
29. BMWi (2019b)
30. Öko-Institut, Fraunhofer ISI, et al. (2019)
31. UBA (2018b)
32. UBA (2018c)
33. UBA (2018d)
34. KBA (2019)
35. BMU (2019)
36. BLE (2018)
37. BDEW (2019)
38. BMEL (2018), UBA (2018f)
39. European Commission (2018b)
40. UBA (2018g)
41. UBA (2018h)

42. BMU (2018b); the GreenTech industry includes: environment-friendly energy generation, storage and distribution; energy efficiency; raw material and material efficiency; sustainable mobility; the circular economy; sustainable water management.
43. UBA (2018i)
44. BMU (2018b)
45. BMU (2018b)
46. BMU (2018c)
47. DIW (2019)
48. BMWi (2018b)
49. BMWi (2018c)
50. BMU (2018c)
51. The Federal Government and governments of the Federal States still have to agree on a formula for allocating these funds to the Federal States.
52. The commission's final report contains a list of concrete project proposals for the lignite-producing Federal States.
53. BMVI (2019)
54. BMU, UBA (2017)
55. BMU (2016a)
56. UBA (2019g)
57. The term "sustainable finance" usually means that environmental and social considerations are taken into account in investment decisions, which leads to more investment in longer-term and sustainable activities. The environmental considerations specifically relate to adaptation to climate change and mitigating its impacts, but also include general environmental aspects and associated risks (for example natural disasters).
58. A positive trend in this direction can be seen in Germany (Figure 44). The volume of sustainable investments and responsible investing has risen sharply in recent years. However, sustainable investments still only account for 3.0 per cent of the total market (source: FNG, 2018).
59. European Commission (2018c)
60. European Commission (2018c)
61. FNG (2018)

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9. Data appendix

Data appendix to figure 05: **Global greenhouse gas emissions in gigatonnes CO_2**

Country / region	1850	1870	1890	1910	1930	1950	1970	1990	2010	2016
US	0.214	0.427	1.13	2.27	2.88	4.07	6.16	6.51	7.01	6.57
EU28 without Germany	0.2939	0.527	0.887	1.373	1.633	1.996	4.17	4.47	3.887	3.432
China	0.0402	0.083	0.112	0.152	0.239	0.359	1.48	3.6	11	12.7
Russia	0.06	0.0683	0.101	0.166	0.279	0.725	2.34	3.78	2.6	2.67
Germany	0.0481	0.124	0.283	0.557	0.597	0.684	1.3	1.26	0.953	0.918
India	0.0611	0.172	0.241	0.275	0.3	0.369	0.601	1.15	2.25	2.87
Brazil	0.00211	0.00498	0.0112	0.038	0.0446	0.1	0.337	0.606	1	1.05
Rest of world	0.20859	0.33372	0.5148	0.879	1.5074	2.797	7.512	11.124	15.7	16.99

Source: PIK (2019)

Data appendix to figure 11: **Trends in greenhouse gases by sector in million tonnes of CO_2 equivalents**

Sektor	1990	2000	2005	2010	2015	2018	2020 Target	2030 Target	2040 Target	2050 Target
Energy	466	386	397	369	348	311		175 – 183		
Transport	163	181	160	153	161	162		95 – 98		
Building	210	167	154	149	124	117		70 – 72		
Industry	284	208	191	188	188	196		140 – 143		
Agriculture	90	75	70	70	74	70		58 – 61		
Other emis-sions	38	29	21	15	11	10		5		
Total (without LULUCF)	1,251	1,045	993	943	907	866				
Targets							751	543 – 562	375	63
LULUCF (in-cluding sinks	-31	-38	-12	-16	-14					

Sources: UBA (2019b), UBA (2019c)

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